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E

MILLWRIGHT'S,

D

NIST'S

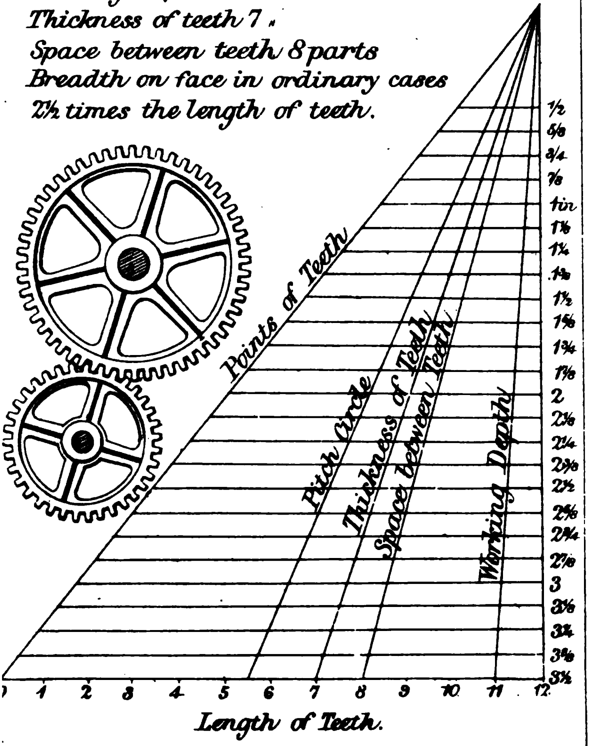
ASSISTANT

LETON.

/6

PROPORTIONS FOR THE CONSTRUCTION OF TOOTHED WHEELS.

Pitch of Teeth divided into 15 equal parts
From pitch circle to points of teeth 5½ parts
Length of teeth 12 parts
Working depth 11 "
Thickness of teeth 7 "
Space between teeth 8 parts
Breadth on face in ordinary cases
2½ times the length of teeth.



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THE ENGINEER'S, MILLWRIGHT'S, AND MACHINIST'S PRACTICAL ASSISTANT;

COMPRISING A

COLLECTION OF USEFUL TABLES, RULES, AND DATA,

COMPILED AND ARRANGED, WITH ORIGINAL MATTER,

BY

WILLIAM TEMPLETON,

AUTHOR OF
"THE OPERATIVE MECHANIC'S WORKSHOP COMPANION,"
ETC., ETC.

Seventh Edition, Carefully Revised, with Additions.

Capio Lumen

LONDON:
CROSBY LOCKWOOD AND CO.,
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1885.

1807.f 15

By the Author of the Present Volume.

THE OPERATIVE MECHANIC'S WORKSHOP COMPANION, and THE SCIENTIFIC GENTLEMAN'S PRACTICAL ASSISTANT. By William Templeton. **Thirteenth Edition, with Mechanical Tables for Operative Smiths, Millwrights, Engineers, &c.; and an Extensive Table of Powers and Roots, &c., &c. 11 Plates. 12mo, 5s. bound.**

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PREFACE

TO THE SIXTH EDITION.

YEAR after year, numerous new and many reconstructed books are introduced to public notice, some for useful information, more for idle recreation, but very few indeed for practical purposes connected with skilled knowledge in mechanical pursuits.

On my return to England in 1877, after an absence of nearly ten years in foreign countries (where works of practical utility on mechanical requirements could not be obtained, nor even heard of), I was astonished to find that my own compilations, published more than thirty years ago, were works still called for by the public, and it therefore occurred to me that a new compilation, embodying, in a concise form, the results of my long practice in various parts of the world, might obtain a share of public appreciation, and be of considerable value to those to whom it is dedicated.

PREFACE

TO THE SEVENTH EDITION.

THIS useful little manual continues to enjoy a sufficient share of public favour to necessitate the issue of a New Edition; and advantage has been taken of the occasion to revise and improve the same by the correction of errors and addition of new matter.

LONDON, *September*, 1884.

THE

Engineer's, Millwright's, & Machinist's

PRACTICAL ASSISTANT.

DEFINITIONS OF ARITHMETICAL SIGNS AS IN COMMON USE.

$=$ Sign of Equality, and signifies equal to, as 7 added to $6 = 13$.

$+$ " Addition, signifies plus or more, as $7 + 8 = 15$.

$-$ " Subtraction, " minus or less, as $14 - 5 = 9$.

$\times$ " Multiplication, " multiply by, as $12 \times 5 = 60$.

$\div$ " Division, " divide by, as $16 \div 4 = 4$. or, $\frac{16}{4} = 4$.

$: \; :: \; :$ Proportion, " as 4 is to 8, so is 12 to 24.

$\sqrt{}$ Sign of Square Root, $\sqrt[3]{}$ " Cube Root, " evolution, or the extraction of roots, as $\sqrt{64} = 8$, and $\sqrt[3]{64} = 4$.

6^2 " To be squared, 6^3 " To be cubed, " involution, or the raising of powers; $6^2 = 36$, and $6^3 = 216$.

$\overline{7 + 5} \times 6 = 72$ signifies line or bar, as 7 added to $5 = 12$, and 12 multiplied by $6 = 72$.

$\sqrt{5^2 - 3^2} = 4$ " that 3 squared taken from 5 squared, the square root of the remainder $= 4$.

$\sqrt[3]{\frac{20 \times 12}{30}} = 2$ " that 20 multiplied by 12 and the product divided by 30, the cube root of the quotient $= 2$.

STANDARD WEIGHTS AND MEASURES OF GREAT BRITAIN AND ITS COLONIES.

THE IMPERIAL MEASURES INTRODUCED JANUARY 1st, 1826.

Avoirdupois, or Commercial Weight.

		MARK.
·10831 cubic inches of pure water, at 62° Fahrenheit, or 27·34375 grs. troy	= 1 dram,	*dr.*
16 drams	= 1 ounce,	*oz.*
16 ounces	= 1 pound,	*lb.*
14 pounds	= 1 stone,	*st.*
2 stones, or 28 pounds	= 1 quarter,	*qr.*
4 quarters, or 112 pounds ...	= 1 hundred-weight,	*cwt.*
20 hundred-weights, or 2,240 pounds	= 1 ton,	*T.*

NOTE.—The stone is principally used in weighing Hay, Straw, and Live Cattle, and commonly called Jockey Weight.

Troy Weight

Is used in weighing Gold, Silver, and Precious Stones, and also in estimating the results of Philosophical experiments.

		MARK.
1·901306 cubic inches of pure water, at 62° Fahrenheit ...	= 480 grains,	*gr.*
24 grains	= 1 pennyweight,	*dwt.*
20 pennyweights	= 1 ounce,	*oz.*
12 ounces	= 1 pound,	*lb.*

NOTE.—Avoirdupois lbs. × 1·21528 = Troy lbs.
„ oz. × ·9115 = „ oz.
Troy lbs. × ·823 = Avoi. lbs.
„ ozs. × 1·1 = „ ozs.
„ grs. × ·03657 = „ drs.

Lineal Measures, or Measures of Length.

The English Standard Yard of 1760, and now lodged in the custody of the Clerk of the House of Commons, is made the standard or unit for all measures of extension whatsoever, and $\frac{1}{36}$ of such yard = 1 inch.

7·92 inches	= 1 link.
12 ,,	= 1 foot.
3 feet	= 1 yard.
6 feet	= 1 fathom.
16½ ,, or 5½ yards	= 1 rod, pole, or perch.
792 inches	= 1 chain.
66 feet	
22 yards, or 4 poles	
220 yards	= 1 furlong.
40 poles, or	
10 chains	
5280 feet	= 1 statute mile.
1760 yards	
320 poles	
80 chains, or	
8 furlongs	
6086¼ feet, or	= 1 nautical mile.
2028¾ yards	

Mean diameter of the Earth=7912 English statute miles.
Circumference of the Earth=24883 miles, or 43794000 yds.
Curvature of the Earth=7·962 inches per mile.

The fathom is chiefly used for seafaring and mining purposes. 8 fathoms = the length of the Navy log-line, and 120 fathoms = a cable's length.

Square, or Superficial Measures.

144 square inches	= 1 square foot.
9 ,, feet	= 1 ,, yard.
272¼ ,, feet, or	= 1 pole or perch.
30¼ ,, yards	
40 poles	= 1 rood.
4840 square yards, or	= 1 acre.
10 ,, chains	
640 acres	= 1 square mile.

Cubic Measures, or Measures of Solidity and Capacity.

1728 cubic inches .... = 1 cubic foot.
27 „ feet .... = 1 „ yard.
5 „ feet .... = 1 barrel bulk of shipping.
42 „ feet .... = 1 ton of shipping.
A load of unhewn timber = 40 cubic feet.
” squared ” = 50 ”
A cord of wood .... = 128 ”

Imperial Measures of Capacity, for all Liquids, Grain, and other Dry Goods.

5 oz. Avoir. of pure water at 62° Fahrenheit ...... = 1 gill = 8·665 cubic in.
4 gills .... = 1 pint = 34·659 ”
2 pints .... = 1 quart = 69·318 ”
4 quarts .... = 1 gallon = 277·274 ”
2 gallons .... = 1 peck = 554·548 ”
4 pecks .... = 1 bushel = 2218·191 ”
8 bushels .... = 1 quarter = 10·27 cubic feet.

Note.—The peck, bushel, and quarter are for dry goods only.

Formerly the Wine gallon contained 231, the Ale gallon 282, and the bushel measure 2150·42 cubic inches.

1 peck of flour .... = 14 lbs. Avoir.
1 bushel ” .... = 56 ” ”
1 barrel ” .... = 196 ” ” or 1¾ cwt.
1 sack ” .... = 280 ” ” ” 2½ ”

Special Wine Measures.

10 gallons = 1 anker.
18 ” = 1 runlet.
42 ” = 1 tierce.
63 ” = 1 hogshead.
84 ” = 1 puncheon
126 ” = 1 pipe.
252 ” = 1 tun.

Special Ale and Beer Measures.

9 gallons = 1 firkin.
18 ” = 1 kilderkin.
36 ” = 1 barrel.
54 ” = 1 hogshead.
72 ” = 1 puncheon
108 ” = 1 butt.

Although thus classified, they are, in trading, generally gauged, and bought or sold in accordance with the number of Imperial gallons therein contained. One cubic foot is equal to 6¼ Imperial gallons.

Dimensions of Imperial Conical Liquid Measures.

	DIAMETERS.				DEPTHS.	
Gill	top	⅝ inch,	bottom	2⅞	3·166	inches.
Half-pint	"	⅞ "	"	3½	4·117	"
Pint	"	1 "	"	4½	5·141	"
Quart	"	1¼ "	"	5¾	6·332	"
Half-gallon	"	1¾ "	"	7	8·234	"
Gallon	"	2 inches,	"	9	10·282	"
Two-gallon	"	2½ "	"	11½	12·665	"

Dimensions of Imperial Cylindrical Dry Measures (not heaped).

DEPTHS EQUAL TO THE DIAMETERS.

Eighth of a peck,	a cylinder of	4·452	inches.
Forpit, or half-gallon	"	5·609	"
Gallon, or half-peck	"	7·067	"
Peck	"	8·904	"
Half-bushel	"	11·219	"
Bushel	"	14·135	"
Quarter	"	28·270	"

Dimensions of Cylindrical heaped Measures, for Coke, Lime, Fish, Fruit, Potatoes, &c.

Half-gallon	= 7¾ inches diameter	=	176	Cubic inches when the measures are heaped.
Gallon	= 9¾ " "	=	352	
Peck	= 12¼ " "	=	704	
Half-bushel	= 15½ " "	=	1407½	
Bushel	= 19½ " "	=	2815½	

3 bushels = 1 sack, and = 4·889 cubic feet.
12 sacks = 1 chaldron = 58·656 " "

NOTE.—The Act directs that the depth of each measure shall not exceed half its diameter, and the height of the cone or heap at least three-fourths of its depth.

Previous to 1835, coals were bought and sold by heaped measures. The bushel was supposed to contain 80 lbs. Avoirdupois, and 28 such bushels to equal 1 ton; but in that year an Act was passed which abolished the system. Now they are estimated by the cwt., or 112 lbs. Avoirdupois, 224 lbs. being 1 sack, and 10 such sacks equal 1 ton.

The average mean weight of different kinds of coal, broken up and properly prepared as practical fuel, is 50 lbs. per cubic foot, and 45 cubic feet the stowage capacity per ton.

Note.—The reason why I here introduce abolished or antiquated coal measures, is because the units of work done by steam-engines were estimated formerly from the consumption of coals by the bushel; now that units of work done are valued by the lb. of coal, comparison of results is not unfrequently required.

FRENCH WEIGHTS AND MEASURES,

AS MOST FREQUENTLY REQUIRED FOR ENGLISH COMPARISONS.

Weights.

1 milligramme = ·015432 English Troy grains.
1 gramme = 15·432 " " "
or ·002205 of a lb. Avoirdupois.
1 kilogramme = 2·2046 lbs. Avoirdupois.

WEIGHTS AS POPULARLY ESTIMATED.

		lbs.	ozs.	drs. Avoirdupois.
1 gramme	=	0	0	0½
1 decagramme.........	=	0	0	5¾
1 hectogramme	=	0	3	8½
1 kilogramme	=	2	3	4⅜

Lineal Measures.

1 millimetre	=	·039371	English inches.
25½ "	=	1	" inch.
1 metre	=	39·371 or 39⅜	" inches.
or	=	3·2809 feet = 3 feet 3⅜ inches.	

Measures of Surface.

1 centiare = 1·196 English sq. yds., or 10·764 English square feet.
9·3 centiares = 100 „ „ feet.
1 are = 119·6 „ „ yards.
40·47 ares = 1 „ statute acre.
1 hectare = 2·47 „ „

Measures of Solidity.

1 millistere .... = ·035317 English cubic feet.
1 stere .... = 35·317 „ „

Measures of Capacity

1 litre .... = 61·027 English cubic inches.

POPULAR MEASURES OF CAPACITY.

		English galls.	qts.	pts.	Imp.
1 litre	=	0	0	1¾	„
1 decalitre	=	2	0	1½	„
1 hectolitre	=	22	0	0	
1 kilolitre	=	220	0	0	

Conversion of Equivalent Measures.

English to French.			French to English.	
Inches ... ×	·0254	= metres	× 39·371	= inches.
Feet ...... ×	·30479	= „	× 3·2809	= feet.
Yards ... ×	·91438	= „	× 1·09363	= yards.
Miles ...... ×	1·6093	= kilometres...	× ·62138	= miles.
Acres,...... ×	·40467	= hectares......	× 2·4711	= acres.
Imp. galls. ×	4·54346	= litres	× ·2201	= gallons.
Cubic ins. ×	·01639	= „	× 61·027	= cubic ins.
Bushels . ×	·36348	= hectolitres .	× 2·75121	= bushels.
Quarters . ×	2·9078	= „ .	× ·3439	= quarters.
Troy grs. . ×	·06480	= grammes ...	× 15·432	= Troy grs.
Troy lbs. . ×	·3732	= kilogrammes	× 2·6792	= Troy lbs.
Avoir. lbs. ×	·4536	= „	× 2·2046	= Avoir. lbs.

USEFUL COMPUTATIONS BY THE SLIDE-RULE.

RECIPROCAL CONVERSION OF FRENCH AND ENGLISH WEIGHTS AND MEASURES.

LENGTH :—Set 5 on B to 127 on A: then, against any given number of inches on B, find on A the equivalent number of millimetres; and *vice versâ*, against any given number of millimetres on A, find on B the equivalent number of inches.

Set 20 on B to 61 on A: then, against any given number of feet on B, find on A the equivalent number of decimetres; and *vice versâ*.

Set 35 on B to 32 on A: then, against any given number of yards on B, find on A the equivalent number of metres; and *vice versâ*.

Set 64 on B to 103 on A: then, against any given number of miles on B, find the equivalent number of kilometres on A; and *vice versâ*.

SUPERFICIES :—Set 31 on B to 200 on A: then, against square inches on B, find square centimetres on A; and *vice versâ*.

Set 183 on B to 17 on A: then, against square feet on B, find square metres on A; and *vice versâ*.

Set 61 on B to 51 on A: then, against square yards on B, find square metres on A; and *vice versâ*.

Set 257 on B to 104 on A: then, against acres on B, find hectares on A; and *vice versâ*.

SOLIDITY :—Set 36 on B to 590 on A: then, against cubic inches on B, find cubic centimetres on A; and *vice versâ*.

Set 19 on B to 538 on A: then, against cubic feet on B, find cubic decimetres on A; and *vice versâ*.

Set 17 on B to 13 on A: then, against cubic yards on B, find cubic metres (or stores) on A; and *vice versâ*.

CAPACITY :—Set 46 on B to 209 on A: then, against Imperial gallons on B, find litres on A; and *vice versâ*.

Set 141 on B to 410 on A: then, against Imperial quarters on B, find hectolitres on A; and *vice versâ*.

WEIGHT :—Set 571 on B to 37 on A : then, against grains on B, find grammes on A ; and *vice versâ.*

Set 97 on B to 44 on A : then, against lbs. Avoirdupois on B, find kilogrammes on A ; and *vice versâ.*

Set 187 on B to 190 on A : then, against tons on B, find milliers (or metric tonnes) on A ; and *vice versâ.*

Set 142 on B to 53 on A : then, against lbs. Troy on B, find kilogrammes on A ; and *vice versâ.*

PRESSURE :—Set 9 on B to 128 on A : then, against lbs. per square inch on B, find kilogrammes per square centimetre on A ; and *vice versâ.*

Set 17 on B to 83 on A : then, against lbs. per square foot on B, find kilogrammes per square metre (or kilogrammetres), on A ; and *vice versâ.*

Set 40 on B to 63 on A : then, against tons per square inch on B, find metric quintals per square centimetre on A ; and *vice versâ.*

INSTRUMENTAL ARITHMETIC.

NUMBERS :—Squares and Roots.

Set 1 on Line C to 1 on Line D : then, against the given number on D, find its square on C ; and *vice versâ,* against the given number on C, find its square root on D.

CUBES AND ROOTS :—Set any given number on C to 1 on D : then, against the given number on D, find its cube on C. If it be necessary, the Zero-point, or 1, on D must be taken as 10 ; in which case the numbers on C are to be reckoned as thousands. Thus set 20 on C at Zero on D, for 10 : then, against 2 (for 20) on D, is found 8, for 8,000 on C.

For the process of finding cube-roots the slide C must be inverted : then, find by inspection the divisions or numbers which exactly coincide on C and D when the given number on C is set to 10 on D ; that number is the required cube-root. Thus set 729 on C (inverted) to 10 on D ; it will be found that the only coincident divisions or numbers on C and D are those marked 9, which number is the cube-root of 729. Again ; set 2,000 on C against 1 (for 10) on D ; the coincident numbers are 12·6, the root. It need scarcely be added, that this process requires patience and precision in the setting of the scales and the determination of the result by inspection

Fourth Powers and Roots :—Against the given number on D find its square, or 2nd power, on C: then, against that 2nd power on D, find the required 4th power on C.

Against the given number on C find its square root on D: then below that square root on C, find the required 4th root on D.

Direct Proportion :—Set the 1st term on B to the 2nd term on A, and find on A the required 4th term against the given 3rd term on B. *Example:* Divide £252, in shares of £14 among four persons, taking 3, 4, 5, and 6 shares respectively. Here the proportion is as 18 to 252, which being set 18 on B to 252 on A; against 3, 4, 5, and 6 on B, are found on A the respective shares, 42, 56, 70 and 84.

Inverse Proportion (Slide B inverted):—Set the 1st term on B to the 2nd term on A; find the answer on A, against the given 3rd term on B. *Example:* If 6 men mow a field in 4 days, how long will 12 men require, all other conditions being alike. Invert B: set 6 on B inverted, to 4 on A; then above 12 on B find the answer on A, 2 days.

It may be useful to note that in all questions of Inverse Proportion, where more requires less, or less more, the factors, being on opposite lines, are always in conjunction; whereas, in Direct Proportion, the factors are in opposition, as well as on opposite lines. Thus the difference is that, in Direct Proportion, it is the quotients, and in Inverse Proportion, the products, of the coincident vertical numbers, that are always equal: *e.g.* in the last two examples, $\frac{252}{18} = 14 = \frac{42}{3}$ or $\frac{56}{4}$ or $\frac{70}{5}$ or $\frac{84}{6}$; and $6 \times 4 = 24 = 12 \times 2$.

Decimals (reading the whole line A as a scale of decimal parts:—Set the numerator of any proper fraction, on A, to the denominator on B: then, against 1, on B, find the decimal equivalent on A. And *vice versâ*, setting any given decimal on A to 1 on B, the equivalent proper fraction in its lowest terms is shown by inspection; A being a line of numerators and B of denominators for all corresponding fractions.

Should no units divisions coincide, the fraction may be found among the tens. Thus, setting the centre 1 on B to 875 on A; the divisions 7 on A and 8 on B are found coincident, giving $\frac{7}{8}$ as the equivalent fraction.

Set any number on A to 1 on B; against 1 on A find on B the decimal representing its reciprocal; *i.e.*, a multiplier, in lieu of a divisor, or *vice versâ*.

Set to any given number or denomination (as shillings, pounds, etc.), on A, the denominator of any given fraction, on B; against the numerator of that fraction, on B, find, on A, the value of that fractional part of the given number or denomination. *Example:* Set 5 on B, to 37 on A; then against 3 on B, find, on A, 22·5, or 3-5ths of 37. To 20 (shillings) on A set 8 on B; then against 5 on B, find, on A, 12·5 shillings, the equivalent of 5-8ths of £1.

To the last division on the right of A (regarded as unity or 1), set any sub-denomination of values to any integer—such as 20 shillings = £1, 12 pence = 1 shilling, 16 oz. = 1 lb., 28 lbs. = 1 quarter, etc., etc.—then read scale of decimal parts on A, and corresponding subdivisions of the given integer on B. *Example:* Set to Zero on the right of A, 24, as the constant denomination of grains equal 1 dwt.; then, against 0·5 on A, will be found 12 grains, the equivalent in grains of 0·5 dwt., and *vice versâ*.

LINEAR MEASURE:—Set 7 on B to 22 on A: then, against any given diameter on B, find corresponding circumference of circle on A; and *vice versâ*, against any given circumference of a circle on A, find corresponding diameter on B.

SUPERFICIES:—Set 17 on D to 227 on C: then, against any given diameter on D, find corresponding area of circle on C; and *vice versâ*.

Set 17 on D to 23 on C (or 377 on D to 1131 on C): then, against any given circumference on D, find corresponding area of circle on C; and *vice versâ*.

Set 44 on B to 39 on A: then, against any given diameter of circle on B, find corresponding side of square of equal area on A; and *vice versâ*.

CUBIC CONTENTS:—Set 50 on B to 312 on A (or 400 on B to 2500 on A): then, against any given number of square feet superficial area of any figure on B, find on A the corresponding number of gallons of water contained in 1 foot deep.

Set 27 on B to 1 on A: then, against any given number of square feet superficial area of any figure on B, find on A the corresponding number of cubic yards contained in 1 foot deep.

Set 10 on D to 34 on C: then, against any given number of inches (diameter of a well or cylinder) on D, find on A the corresponding number of lbs. weight of water in contents at 1 foot deep.

Set 59 on D to 19 on C: then, against any given number of inches (diameter of a well or cylinder) on D, find on C the corresponding number of cubic feet in contents at 1 foot deep.

Set 17 on D to 226 on C: then, against any given number of feet (diameter of a well or cylinder) on D, find on C the corresponding number of cubic feet in contents at 1 foot deep.

Set 33 on D to 32 on C: then, against any given number of feet (diameter of a well or cylinder) on D, find on C the corresponding number of cubic yards in contents at 1 foot deep.

Set 10 on D to 490 on C: then, against any given number of feet (diameter of a well or cylinder) on D, find on C the corresponding number of gallons in contents at 1 foot deep.

TIMBER:—Set 144 on A to any given number of square inches in section of scantling on B: then, against any given number of lineal feet of such scantling, on A, find on B the corresponding number of cubic feet in contents.

Set 12 on D against any number of lineal feet of round timber on C: then, against any given number of inches (quarter girt) on D, find on C the corresponding number of cubic feet in contents.

BRICKWORK:—Set 1633 on A to any given number of quarter-bricks in thickness of brickwork on B: then, against any given number of superficial feet of brickwork (of such thickness) on A, find on B the corresponding number of standard rods of brickwork (1½ bricks thick).

Set 144 on A to any thickness (in quarter-bricks) on B: then, against any given number of superficial feet of such brickwork on A, find on B the corresponding number of cubic yards of brickwork in the contents.

PRICES :—Set 144 on A to any given number of pence on B (price of timber per cubic foot): then, on B find the number of pence, price per lineal foot, against and corresponding to any given number of square inches (sectional area of scantling) on A.

Set 7 on B to 8 on A: then, against any given number of pounds sterling (the price of a standard rod of brickwork) on A, find on B the corresponding number of pence (price per superficial foot of standard thickness, *i.e.*, 1½ bricks); and *vice versâ*.

Set 51 on B to 90 on A: then, against any given price in pounds per standard rod of brickwork on B, find on A the equivalent price per cubic yard in shillings; and *vice versâ*.

RIGGERS :—Set any given number of inches (diameter of a pulley on a driving shaft) on A, to any given number of revolutions (required speed of a countershaft) on B: then, against any given number of revolutions of driving shaft on B, find on A the number of inches (required diameter of pulley on countershaft, to maintain the given ratio of speeds).

GEARED WHEELS :—Set any given pitch of wheel on B to 3·14 on A (or take 7 times the pitch on B and set it to 22 A): then, against any given diameter of wheel (in inches) on B, find on A the number of teeth; and *vice versâ*, against any given number of teeth on A, find on B the diameter of wheel in inches.

Set any number of inches diameter of wheel on B to any number of teeth on A: then, against 3·14 on A, find on B the pitch of teeth; or against 22 on A find a number, which divide by 7 to give the pitch of teeth.

Set given diameter of driving wheel on B to the required speed or number of revolutions (per minute) of the driven wheel on A: then, against the given speed or number of revolutions per minute, of the driving wheel on A, find on B the required diameter of the driven wheel.

Set the given distance between the centres of a pair of geared wheels in inches (*i.e.*, the sum of their semi-diameters) on A to the sum of their given speeds (or number of revolutions per minute) on B: then, against each of the given speeds on B, find on A the required semi-diameter of the other wheel.

Ex.—The distance from centre to centre of a pair of geared wheels is intended to be 100 inches, and their respective speeds are proposed to be 30 and 20 revolutions per minute, respectively; the sum of the speeds being 50. Then set 100 on A to 50 on B. Against 20 on B will be found 40 on A, the number of inches in the semi-diameter of the smaller wheel; and similarly, against 30 on B will be found 60 on A, the semi-diameter of the larger wheel in inches.

CONDENSING ENGINES:—Add 3·73 to the product of the pressure, in lbs. per circular inch, multiplied by 0·8; and multiply the sum by the speed of the piston in feet per minute: set the resulting product, on C, to 182 on D; against any given diameter of cylinder, in inches, on D, find on C, the effective horse-power, and *vice versâ*.

HIGH PRESSURE ENGINES:—From the pressure, in lbs. per circular inch, deduct 4 lbs., due to the work of the engine itself, and multiply the remainder (effective steam pressure) by the speed of the piston in feet per minute: set the resulting product on C, to 182 on D: against any given diameter of cylinder, in inches, on D, find on C, the effective horse-power, and *vice versâ*.

The foregoing selection of rules will suffice to exemplify the use of the slide-rule in obtaining, without resort to calculation by actual figures, with approximate accuracy sufficient for all practical purposes, a great variety of useful results. Every engineer, familiar with the principles and use of the slide-rule, can easily determine methods of its application to the solution of many other similar problems of every-day occurrence.

Tables of Decimal Equivalents to Fractional parts of Lineal Measures British.

1 Inch = Unity, and divided into 32 parts.

·96875	Are equal to	7/8 & 3/32	·625	Are equal to	5/8	·28125	Are equal to	1/4 & 1/32
·9375		7/8 & 1/16	·59375		1/2 & 3/32	·25		1/4
·90625		7/8 & 1/32	·5625		1/2 & 1/16	·21875		1/8 & 3/32
·875		7/8	·53125		1/2 & 1/32	·1875		1/8 & 1/16
·84375		3/4 & 3/32	·5		1/2	·15625		1/8 & 1/32
·8125		3/4 & 1/16	·46875		3/8 & 3/32	·125		1/8
·78125		3/4 & 1/32	·4375		3/8 & 1/16	·09375		3/32
·75		3/4	·40625		3/8 & 1/32	·6625		1/16
·71875		5/8 & 3/32	·375		3/8	·03125		1/32
·6875		5/8 & 1/16	·34375		1/4 & 3/32	·015625		1/64
·65625		5/8 & 1/32	·3125		1/4 & 1/16	·0078125		1/128

1 Foot = Unity, and divided into 48 parts.

·9791	Are equal to	11¾	·62497	Are equal to	7½	·27083	Are equal to	3¼
·95827		11½	·60313		7¼	·25		3
·93748		11¼	·5833		7	·2291		2¾
·9166		11	·5625		6¾	·20827		2½
·8958		10¾	·54167		6½	·18743		2¼
·87497		10½	·52083		6¼	·1666		2
·85413		10¼	·5		6	·1458		1¾
·8333		10	·4791		5¾	·12497		1½
·8125		9¾	·45827		5½	·10413		1¼
·79167		9½	·43743		5¼	·0833		1
·77083		9¼	·4166		5	·07292		7/8
·75		9	·3958		4¾	·0625		3/4
·7291		8¾	·37497		4½	·05208		5/8
·70827		8½	·35413		4¼	·04167		1/2
·68723		8¼	·3333		4	·03125		3/8
·6666		8	·3125		3¾	·02083		1/4
·6458		7¾	·29167		3½	·01042		1/8

1 Yard = Unity, and divided into 36 parts.

·9722	Are equal to	35	·6389	Are equal to	23	·3055	Are equal to	11
·9444		34	·6111		22	·2778		10
·9167		33	·5833		21	·25		9
·8889		32	·5556		20	·2222		8
·8611		31	·5278		19	·1944		7
·8333		30	·5		18	·1667		6
·8056		29	·4722		17	·1389		5
·7778		28	·4444		16	·1111		4
·75		27	·4167		15	·0833		3
·7222		26	·3889		14	·0555		2
·6944		25	·3611		13	·0278		1
·6667		24	·3333		12	·01389		½

1 Pound Avoirdupois=Unity, and divided into 16 parts: 16 drams = 1 oz., and 16 ozs. = 1 pound.

·0625 = 1 dram, or oz.
·125 = 2 ,, ,,
·1875 = 3 ,, ,,
·25 = 4 ,, ,,
·3125 = 5 ,, ,,
·375 = 6 ,, ,,
·4375 = 7 ,, ,,
·5 = 8 ,, ,,

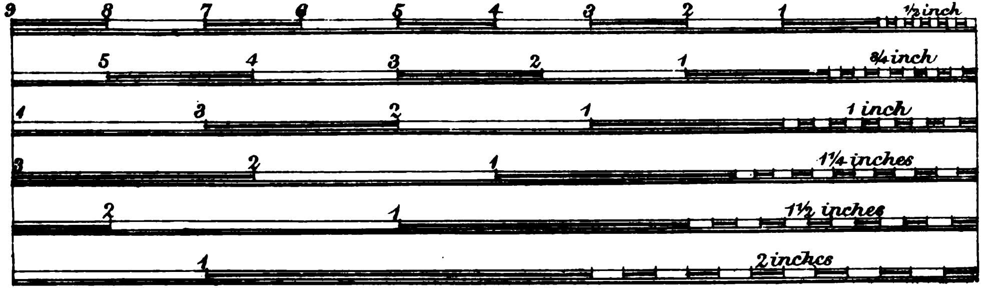
·5625 = 9 drams, or ozs.
·625 = 10 ,, ,,
·6875 = 11 ,, ,,
·75 = 12 ,, ,,
·8125 = 13 ,, ,,
·875 = 14 ,, ,,
·9375 = 15 ,, ,,
1 oz. or lb. = 16 ,, ,,

Common Fractions, with Decimal Equivalents.

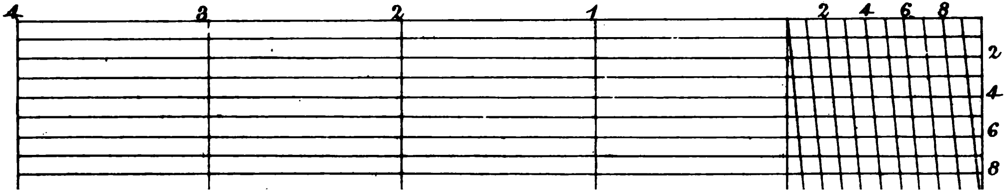
$\frac{1}{4} = \frac{2}{8} = \frac{3}{12}$ .... = ·25
$\frac{1}{3} = \frac{2}{6} = \frac{3}{9}$ .... = ·333
$\frac{1}{2} = \frac{2}{4} = \frac{3}{6} = \frac{4}{8} = \frac{6}{12}$ = ·5
$\frac{2}{3} = \frac{4}{6} = \frac{6}{9}$ .... = ·666
$\frac{3}{4} = \frac{6}{8} = \frac{9}{12}$ .... = ·75

$\frac{1}{5}$ = ·2
$\frac{1}{6}$ = ·1666
$\frac{1}{7}$ = ·1428
$\frac{1}{8}$ = ·125
$\frac{1}{9}$ = ·111

Scales of Feet and Inches.



Decimal Scale of Inches.



Decimal Approximates for the facilitation of practical calculations in British Measures.

Avoirdupois lbs.	×	·009	=	hundred-weights.
„ „	×	·00045	=	tons.
Circum. of a circle...	×	·31831	=	the diameter.
Circular inches	×	·00546	=	square feet.
Cube of diam. of a sphere	×	·5236	=	the solidity.
Cubic inches	×	·00058	=	cubic feet.
„ feet	×	·03704	=	„ yards.
„ inches	×	·003607	=	Imperial gallons.
„ feet	×	6·232	=	„ „
Cylindrical inches ...	×	·0004546	=	cubic yards.
„ „ ...	×	·002832	=	Imperial gallons.
„ feet	×	·02909	=	cubic yards.
„ feet	×	4·895	=	Imperial gallons.
Diam. of a circle ...	×	3·1416	=	the circumference.
„ „ ...	×	·8862	=	side of equal square.
„ „ ...	×	·7071	=	side of inscribed sq.
Side of a square......	×	1·4142	=	dia. of circum. circle
Diam. of a sphere ...	×	·806	=	dimensions of equal cube.
„ „ ...	×	·6667	=	length of equal cylinder.
Lineal feet	×	·00019	=	English statute miles
„ yards	×	·000568	=	„ „ „
Side of a square......	×	1·1284	=	diameter of circle of equal area.
„ „	×	3·545	=	circum. of circle of equal area.
Square of diameter...	×	·7854	=	area of equal circle.
„ root of area...	×	1·12837	=	diam. of equal circle.
„ inches	×	·00694	=	square feet.
„ yards	×	·0002067	=	English statute acres.
Sq. of dia. of a sphere	×	3·1416	=	convex surface of a sphere.

183·346 circular inches equal 1 square foot.
2200 cylindrical inches equal 1 cubic foot.

Tables of Specific Gravities,

OR WEIGHTS OF BODIES WHOSE MAGNITUDES ARE EQUAL, BUT OF UNEQUAL DENSITIES.

One cubic foot of pure fresh water at 62° Fahrenheit = 1000 ounces Avoirdupois; hence it is conveniently, and with propriety, adopted as the standard of comparison to which the densities of other bodies are generally referred, and also the means by which to ascertain the densities of other bodies hitherto untabulated.

Atmospheric air = ·0768, or is 820 times lighter than water.

Metals.	Weight, water being 1000.	Cubic inches in lbs. Avoir.	Weight of 1 cub. in. in lbs.
Antimony, cast	6700	4·134	·242
Bismuth ,,	9810	2·818	·3545
Brass, average, ,,	8357	3·308	·3023
Bronze ,,	8459	3·268	·306
Cadmium	8600	—	—
Copper, cast	8667	3·19	·3135
,, wrought	8788	3·146	·3178
Gold, pure	19258	1·435	·6965
Gun-metal, cast	8561	3·23	·3096
Iron ,,	7244	3·814	·2622
,, bar	7701	3·592	·2792
,, wrought	7792	3·548	·282
Lead, cast	11352	2·435	·415
Mercury at 32° Fahrenheit	13619	—	—
,, 60° ,,	13580	2·035	·4914
,, 212° ,,	13375	—	—
Nickel	8270	3·342	·3
Platinum	20978	1·318	·759
Silver, pure	10474	2·633	·3788
Steel, soft	7780	3·554	·281
,, hardened	7840	3·527	·2835
Tin, cast	7291	3·79	·2636
Zinc, ,,	7190	3·845	·26

VARIOUS BODIES.	Sp. Gr.	Cub. ft. lbs.	Cub. feet = 1 T.
Brick, red, common	1684	105	21·4
„ fire, Welsh	1931	120·7	18·5
Burrs, French, average	2484	151	14
Clay, common	1920	120	18·7
Coal, average	1319	82·4	27·2
Coke, dry	755	47	47·6
Glass, plate	2453	153·3	14·6
Granite, average	2651	165·7	13·5
Gravel, „	1920	120	18·7
Ice, from fresh water	970	60½	37
Marble, average	2720	170	13
Salt, dry	2130	134·5	18
Sand, river	1520	95	25
Slate, average	2800	112·5	19·2
Sandstone, „	2350	147	15 2
Tallow, „	942	59	38

LIQUIDS.	Sp. Gr.	Weight of Im. gal. lbs.	Weight of cub. in. lbs.
Alcohol of Commerce	825	8·2	·0296
„ Absolute	797	7·9	·0285
Acid, Sulphuric	1850	18·5	·0667
„ Nitric	1217	12·7	·0458
„ Muriatic	1200	12	·0433
„ Citric	1034	10·3	·0371
Ether, Nitric	908	9·1	·0328
„ Muriatic	729	7·3	·0263
Oil, Linseed	940	9·4	·0389
„ Olive	915	9·2	·0332
„ Rapeseed	919	9·3	·0335
„ Whale	923	9·4	·0339
Sea Water, average	1028	10·3	·0371
Spirits, proof	922	9·2	·0332
„ of Wine	830	8·3	·0299
Tar, from Wood	1015	10·1	·0364
Turpentine	870	8·7	·0314
Vinegar, distilled	1009	10	·0361
Wine, Bordeaux	994	9·94	·0358
„ Port	997	9·97	—

TIMBER, SEASONED.	Sp. Gr.	Pounds per cub. ft.	Cubic ft. = 1 Ton.
Alder	736	46	48¾
Apple-tree	792	49½	45¼
Ash	845	52	43
Beech	852	53¼	42
Birch, English	792	49½	45¼
„ black, American	648	40½	55
Blackwood, Australian	662	41½	54
Blue Gum, „	1100	68¾	32½
Box, Dutch	1328	83	27
„ French	912	57	39
Cedar, American	561	35	64
„ Sydney	560	34½	64
„ Canadian	910	57	39¼
Cherry-tree	715	45	50
Chestnut	610	38	59
Cork	240	15	149
Cowrie Pine, New Zealand	512	32	70
Crab-tree	768	48	46½
Ebony, Indian	1208	75½	29
„ American	1331	83	27
Elm	673	42	53
Hawthorn	610	38	59
Holly and Hornbeam, each	760	47½	47¼
Iron Bark, Australian	1233	77	29
Laburnum	920	57½	39
Lance-wood	1023	64	35
Larch	530	31	72¼
Lemon-tree	704	44	51
Lignum Vitæ	1336	83½	26⅓
Lime-tree	760	47½	47¼
Logwood	913	57	39½
Mahogany, Spanish	720	45	50
„ Honduras	560	35	64
Maple	752	47	47½
Oak, English	934	58	38⅓
„ American	672	42	53⅓

TIMBER, SEASONED.	Sp. Gr.	Pounds per cub. ft.	Cubic ft. = 1 Ton.
Oak, African	944	59	38
Orange-tree	705	44	49¾
Pear-tree	660	41	54½
Pine, pitch	736	46	48¾
„ red	672	42	53
„ white	456	28½	78½
„ yellow	448	28	80
Poona	640	40	35
Poplar	384	24	93¼
Plum-tree	785	49	45¾
Red Gum, Australian	901	56	40
Rosewood, black	1280	80	28
Sycamore	624	39	57½
Teak	750	46	48⅓
Walnut	671	42	53⅓
Willow	585	36½	61¼
Yew, Spanish	807	50½	44¼
„ Dutch	788	49¼	45

Elastic Fluids or Gases, Atmospheric Air being 1000.

Ammoniacal Gas	·500
Azote, or Nitrogen	·969
Carburetted Hydrogen	·491
Hydrogen	·074
Oxygen, mean	1·044
Steam of water at 212° Faht.	·500
Sulphuretted Hydrogen	1·777
Sulphurous Acid Gas	2·193
Vapour of Alcohol	1·613

Useful units of fresh water at a mean temperature.

		Avoir.			Avoir.
1 cubic	in. =	·03617 lbs.	1 cylin.	in. =	·02832 lbs.
12 ,,	ins. =	·434 ,,	12 ,,	ins. =	·341 ,,
1 ,,	foot =	62·5 ,,	1 ,,	foot =	49·1 ,,
1·8 ,,	feet =	1 cwt.	2·282 ,,	feet =	1 cwt.
35·84 ,,	feet =	1 ton.	45·64 ,,	feet =	1 ton.

27·648 cubic inches .... = 1 lb. Avoir.
1 gallon (Imperial) ...... = 10 ,, ,,
11·2 gallons ,, ... = 1 cwt.
224 ,, ,, ... = 1 ton.
277·274 cubic inches .... = 1 Imperial gallon.
12 ,, ,, ... = ·043284 ,, ,,
1 ,, inch ... = ·003607 ,, ,,
1 ,, foot .. = 6·232 ,, gallons.
353 cylindrical inches = 1 Imperial gallon.
12 ,, ,, = ·034 ,, ,,
1 ,, ,, = ·002832 ,, ,,
1 ,, foot = 4·895 ,, gallons.

Sea water, average density.

26·895 cubic inches ...... = 1 lb. Avoir.
1 gallon (Imperial)...... = 10·25 ,,
10·93 ,, ,, ... = 1 cwt.
218·6 ,, ,, ... = 1 ton.
1 cubic foot .... = 64·2 lbs. Avoir.
34·9 ,, feet .... = 1 ton.

Comparative densities and degrees of Saltness of Sea water from various localities, that of the British Channel being 1·00.

The Baltic Sea	= 0·19	At the Equator	= 1·12
The Black Sea	= 0·61	North Atlantic	= 1·16
The Irish Channel .	= 0·96	Sea of Marmora ...	= 1·18
The Mediterannean	= 1·11	South Atlantic	= 1·20

The following Examples show the utility of the preceding Tables, viz., Decimal Equivalents, Decimal Approximates, and Decimal Weights of a cubic inch in Tables of Specific Gravities.

Ex. 1 Required, the superficial contents, in square feet of any right-lined figure whose breadth at one end equals 2 ft. 5¾ inches; at the other end 1 ft. 10½ inches, and length 5 ft. 3¼ inches.

(See Tables of Decimal Equivalents, page 19.)

2·4791 = 2 feet 5¾ inches.
+ 1·87497 = 1 „ 10½ „
÷ 2) 4·35407
2·177 mean breadth.
× 5·27 = 5 feet 3¼ inches.
15239
4354
10885
11·47279 ft. superficial surface.

Again: 2 feet 5¾ inches = 29·75 inches.
and 1 foot 10½ „ = + 22·5 „
÷ 2) 52·25
Mean breadth 26·125
5 feet 3¼ inches = × 63·25
130625
52250
78375
156750
Square inches 1652·4|0625
(See Table, page 21.) × ·00694 or, ·007
66096
148716
99144
Square feet nearly 11·467656 as before.

Ex. 2. A piece of wood as a pattern for a casting of iron 15$\frac{7}{16}$ inches in length, 7$\frac{1}{8}$ inches in breadth, and $\frac{3}{4}$ and $\frac{3}{32}$ inches in thickness, what are its contents in cubic inches? Also, what will its weight be in cast iron, taking the cubical contents of pattern by which to compute the weight, because cast iron contracts in the ratio of $\frac{1}{8}$ of an inch per lineal foot generally?

(See Table of Decimal Equivalents, p. 19.)

```
                   7⅛ =     7·125
               ¾ & 3/32 =    ·84375  ×
                          ─────────
                             35625
                            49875
                           21375
                          28500
                         57000
                         ───────────
                         6·01171875
        15 7/16 inches =     15·4375  ×
                       ─────────────
                        3005859375
                       4208203125
                      1803515625
                     2404687500
                    3005859375
                    601171875
                  ─────────────────
        Contents  92·8059 08203125 in cubic inches.
(See Table, page 22.)  ·2622
                  ───────
                  1856118
                 1856118
                5568354
               1856118
               ────────────
               24·33370698  weight in lbs. Avoir.
               ════════════
```

In practical operations such minute computations are not always required, approximations frequently being equally adapted, particularly when time is of consequence; hence, in multiplication of decimals, or of whole numbers and decimals, contracted multiplication is oftentimes had recourse to, the following being the common rule:—

The multiplicand is placed in the usual form; then place the unit figure of the multiplier under that figure of the multiplicand whose place is the last to be retained in the product, and dispose of the rest so that they may all stand in contrary order to that in which they are usually placed. Then, in multiplying, reject all the figures on the right hand of the multiplying digit, and set down each product so that the right hand figures may fall in a vertical line; and observe that the first figure of every line must be increased with what would arise (by carrying 1 from 5 to 14, 2 from 15 to 24, 3 from 25 to 34, 4 from 35 to 44, &c.) from the product of the two preceding figures when you begin to multiply, and the sum is the product required; but the following example, worked out at length, may more advantageously elucidate:—

$7\frac{1}{8}$ = 7·125
$\frac{3}{4}$ & $\frac{3}{32}$ = 57348 or ·84375 reversed.
57000
2850
214
50
3
Product 6·01161 or sectional area in sq. inches.
$15\frac{7}{16}$ = 573451 or 15·4375 reversed.
601171
300586
24047
1803
421
30
Product 92·8058 Solidity in cubic inches.
Weight of cubic inch 2262 or ·2622 reversed.
185612
55682
1856
186
Product 24·3336 in lbs. Avoirdupois.

Ex. 3. Suppose the above casting is too light, and too long as a counterpoise, it being required 32 lbs. in weight, what length must it be in lead?

Areal section of pattern = 6 inches.
Weight of 1 cubic inch of lead = ·415 lbs.
Then ·415 × 6 = 2·49, and 32 ÷ 2·49 = 12·835 inches in length.

Ounces of dry deal or yellow pine as patterns for castings or forgings, &c.

Multiplied by 1·011 = lbs. Avoirdupois in cast iron.
" " 1·075 = " " wrought iron.
" " 1·175 = " " brass.
" " 1·21 = " " copper.
" " 1·584 = " " lead.

Ex. Suppose a model or pattern of dry pine equal 3 lbs. 5 ozs. Avoirdupois, what weight will the same be as a forging of wrought iron?

3 lbs. 5 ozs. = 53 ozs. × 1·075 = 56·975 lbs., or 56 lbs. 15 ounces.

Comparative Densities of various Metals.

Bar or Plate Iron being		1·000
Cast Iron..............	=	·942
Steel, soft	=	1·007
" hard	=	1·016
Brass, cast	=	1·083
Copper, "	=	1·123
" wrought......	=	1·140
Lead....................	=	1·487

Ex. Required, the weight of 1 lineal foot of round wrought copper to replace 1 lineal foot of round bar iron 1½ inches diameter.

As per table of bar iron, 1 foot of 1½ in. round = 5·92 lbs., and 5·92 × 1·14 = 6·74 lbs. of copper.

Weight of Square and Round Bar Iron in lbs. Avoirdupois per lineal foot.

Inches.	Square.	Round.	Inches.	Square.	Round.
¼	·210	·165	3 inches	30·15	23·68
5/16	·327	·257	3⅛	32·72	25·70
⅜	·471	·370	3¼	35·39	27·80
7/16	·641	·504	3⅜	38·16	29·97
½	·838	·658	3½	41·04	32·23
9/16	1·06	·833	3⅝	44·02	34·58
⅝	1·31	1·03	3¾	47·10	37·00
11/16	1·58	1·25	3⅞	50·25	39·51
¾	1·89	1·48	4 inches	53·60	42·10
13/16	2·21	1·74	4⅛	57·00	44·78
⅞	2·56	2·02	4¼	60·51	47·54
15/16	2·94	2·32	4⅜	64.12	50·17
1 inch	3·35	2·64	4½	67·82	53·28
1⅛	4·24	3·33	4⅝	71·66	56·29
1¼	5·24	4·12	4¾	75·71	59·38
1⅜	6·33	4·98	4⅞	79·60	62·54
1½	7·54	5·92	5 inches	83·75	65·80
1⅝	8·85	6·95	5¼	92·33	72·54
1¾	10·26	8·06	5½	101·33	79·60
1⅞	11·78	9·25	5¾	110·76	87·00
2 inches	13·40	10·53	6 inches	120·60	94·72
2⅛	15·13	11·89	6¼	130·85	102·80
2¼	16·96	13·32	6½	141·56	111·17
2⅜	18·93	14·85	6¾	152·63	119·90
2½	21·00	16·45	7 inches	164·16	129·00
2⅝	23·09	18·14	7½	188·42	148·00
2¾	25·33	19·90	8 inches	214·40	168·40
2⅞	27·69	21·75	9 inches	271·28	213·12

Weights of Round Bar Iron, frequently required for hurried purposes of estimation, &c.

Lengths of the Iron in feet.	Diameters in inches.						
	1 inch	1¼	1½	1¾	2 inches	2¼	2½
	Weights in cwts., qrs., lbs. Avoirdupois.						
1	2·6	4·2	5·9	8·6	10·5	13·3	16·4
2	5·3	8·3	11·8	16·2	21	26·6	1 5
3	7·9	12·4	17·7	24·2	1 4	1 12	1 22
4	10·6	16·5	23·7	1 4	1 14	1 25	2 10
5	13·2	20·6	1 2	1 12	1 25	2 11	2 27
6	15·8	24·7	1 8	1 20	2 8	2 24	3 15
7	18·3	1 1	1 13	2 1	2 18	3 9	1 0 3
8	21·2	1 5	1 20	2 9	3 1	3 23	1 0 20
9	23·8	1 9	1 26	2 17	3 11	1 0 8	1 1 8
10	26·4	1 13	2 3	2 25	3 22	1 0 21	1 1 25
15	1 12	2 6	3 5	1 0 9	1 1 18	1 3 4	2 0 23
20	1 25	2 26	1 0 7	1 1 21	1 3 14	2 1 15	2 3 21
30	2 23	1 0 12	1 2 10	2 0 18	2 3 8	3 2 8	4 1 18
40	3 23	1 1 25	2 0 13	2 3 14	3 3 1	4 3 1	5 3 14
50	1 0 20	1 3 10	2 2 16	3 2 11	4 2 22	5 3 22	7 1 10
60	1 1 18	2 0 23	3 0 20	4 1 8	5 2 16	7 0 16	8 3 7
70	1 2 17	2 2 8	3 2 22	5 0 4	6 2 9	8 1 9	10 1 4
80	1 3 15	2 3 21	4 0 26	5 2 19	7 2 2	9 2 2	11 3 0
90	2 0 14	3 1 6	4 3 1	6 1 25	8 1 24	10 2 23	13 0 25
100	2 1 12	3 2 20	5 1 4	7 0 22	9 1 17	11 3 16	14 2 21

Weights of Flat Bar Iron per lineal foot, in lbs. Avoirdupois.

Breadth in inches.	Thickness in parts of an inch.								
	⅛	3/16	¼	⅜	½	⅝	¾	⅞	1 in.
⅜	·16	·24	·31						
½	·21	·31	·42	·63					
⅝	·26	·39	·52	·78	1·05				
¾	·32	·47	·63	·94	1·26	1·51			
⅞	·37	·55	·73	1·10	1·46	1·83	2·20		
1 in.	·42	·63	·84	1·26	1·68	2·09	2·51	2·93	
1⅛	·47	·70	·94	1·41	1·88	2·36	2·83	3·30	3·77
1¼	·52	·78	1·05	1·57	2·09	2·62	3·14	3·67	4·19
1⅜	·58	·86	1·15	1·73	2·30	2·88	3·45	4·04	4·61
1½	·63	·94	1·26	1·89	2·51	3·14	3·77	4·40	5·03
1⅝	·68	1·02	1·36	2·04	2·72	3·40	4·09	4·77	5.45
1¾	·73	1·10	1·47	2·20	2·93	3·66	4·41	5·13	5·87
1⅞	·78	1·18	1·57	2·36	3·14	3·93	4·71	5·50	6·29
2 in.	·84	1·26	1·68	2·52	3·35	4·19	5·02	5·87	6·70
2¼	·94	1·41	1·88	2·83	3·77	4·71	5·66	6·60	7·54
2½	1·05	1·57	2·09	3·14	4·19	5·23	6·29	7·33	8·40
2¾	1·15	1·73	2·30	3·45	4·61	5·76	6·91	8·07	9·22
3 in.	1·26	1·88	2·51	3·77	5·03	6·28	7·54	8·80	10·05
3¼	1·36	2·04	2·72	4·08	5·44	6·80	8·17	9·53	10·89
3½	1·47	2·20	2·93	4·40	5·86	7·33	8·80	10·26	11·73
3¾	1·57	2·36	3·14	4·71	6·28	7·85	9·43	11·00	12·57
4 in.	1·68	2·51	3·35	5·03	6·70	8·38	10·05	11·73	13·40
4¼	1.78	2·67	3·56	5·34	7·12	8·90	10·68	12·46	14·24
4½	1·89	2·82	3·77	5·65	7·54	9·42	11·31	13·20	15·08
4¾	1·99	2·98	3·97	5·97	7·96	9·95	11·94	13·93	15·92
5 in.	2·10	3·14	4·19	6·29	8·38	10·47	12.60	14·66	16·75
5½	2·30	3·45	4·60	6·91	9·22	11·52	13·82	16·20	18·43
6 in.	2·52	3·77	5·02	7·54	10·05	12·56	15·08	17·60	20·11

Weight of a superficial foot of Boiler Plate Iron, Sheet Iron, Copper and Brass, in lbs. Avoirdupois.

Thickness in parts of an inch.	Iron.		Thickness by Wire Gauge.	No	Iron.	Copper.	Brass.	Thickness by Wire Gauge.	No	Iron.	Copper.	Brass.
	1/32	1·25		1	12·50	14·50	13·75		16	2·50	2·90	2·75
	1/16	2·5		2	12·00	13·90	13 20		17	2·18	2·52	2·40
	1/8	5·0		3	11·00	12·75	12·10		18	1·86	2·15	2·04
	3/16	7·5		4	10·00	11·60	11·00		19	1·70	1·97	1·87
	1/4	10·0		5	8·74	10·10	9·61		20	1·54	1·78	1·69
	5/16	12·5		6	8·12	9·40	8 93		21	1·40	1·62	1·54
	3/8	15·0		7	7·50	8·70	8·25		22	1·25	1·45	1·37
	7/16	17·5		8	6·86	7·90	7·54		23	1·12	1·30	1·23
	1/2	20·0		9	6·24	7·20	6·86		24	1·00	1·16	1·10
	9/16	22·5		10	5·62	6·50	6·18		25	·90	1·04	·99
	5/8	25·0		11	5·00	5.80	5.50		26	·80	·92	·88
	11/16	27·5		12	4·38	5·08	4·81		27	·72	·83	·79
	3/4	30·0		13	3·75	4·34	4·12		28	·64	·74	·70
	7/8	35·0		14	3·12	3·60	3·43		29	·56	·64	·61
	1 in.	40·0		15	2·82	3·27	3·10		30	·50	·58	·55

Weight of a lineal foot of Common Angle Iron, for the construction of Steam-boilers, Tanks, &c., in lbs. Avoirdupois.

Breadth, in inches.	Weight, in lbs.	Breadth, in inches.	Weight, in lbs.
3½	14·	2¼	5·
3¼	11·75	2	3·9
3	10·4	1¾	3·3
2¾	8·3	1½	2·7
2½	6·5	1¼	1·8

Weight of a lineal foot of Plain Cast Iron Pipes, without belts or beads, in lbs. Avoirdupois.

Diameter of Bore in inches.	Thickness of Metal in inches.							
ins.	3/8	1/2	5/8	3/4	7/8	1 inch	1 1/8	1 1/4
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
2	8·8	12·4	16·3	20·4				
2½	10·7	14·9	19·4	24·1				
3	12·5	17·4	22·4	27·8	33·6	39·7	46·0	
3½	14·4	19·9	25·5	31·5	37·9	44·7	56·6	
4	16·2	22·3	28·6	35·2	42·3	49·6	57·1	65·1
4½	18·1	24·8	31·7	38·9	46·7	54·6	62·7	71·2
5	20·0	27·3	34·9	42·7	51·0	59·5	68·3	77·4
5½	21·9	29·8	38·0	46·4	55·3	64·5	73·9	83·4
6	23·7	32·2	41·1	50·1	59·6	69·4	79·4	89·8
6½	25·6	34·7	44·2	53·8	63·9	74·4	85·0	96·0
7	27·4	37·2	47·3	57·5	68·3	79·3	90·6	102·2
7½	29·3	39·7	50·4	61·2	72·6	84·3	96·2	108·4
8	31·1	42·2	53·5	65·0	77·0	89·3	101·8	114·6
8½	33·0	44·7	56·6	68·7	81·3	94·3	107·4	120·8
9	34·9	47·1	59·6	72·4	85·7	99·2	112·9	127·0
9½	36·8	49·6	62·7	75·6	90·0	104·2	118·5	133·2
10	38·6	52·1	65·8	79·9	94·3	109·1	124·1	139·4
10½		54·6	68·9	82·8	98·6	114·1	129·7	145·6
11		57·0	72·0	87·3	103·0	119·0	135·2	151·8
11½		59·6	75·1	90·4	107·3	124·0	140·8	158·0
12		62·0	78·2	94·7	111·7	128·9	146·4	164·2
13			84·4	102·2	120 4	138·8	157·5	176·6
14			90·6	109·6	129·0	148·8	168·7	189·0
15			96·8	117·0	137·7	158·7	179·8	201·4
16				124·5	146·4	168·6	181·0	213·8
17				131·9	155·1	178·5	202·1	224·2
18				138·2	162·1	186·5	211·2	236·2
20					179·3	206·2	233·3	260·8
22						225·8	255·4	285·4
24						245·5	277·3	310·0

NOTE.—Two flanges are generally estimated as equal to one foot of pipe, but the weights of sockets, belts, and beads are entirely uncertain.

To find the weight of any other diameter of cast iron pipe:—

Rule.—Add together the outside and inside diameters in inches, multiply the sum by their difference and by 2·48, the product is the weight in lbs. Avoirdupois.

Ex. Required the weight of a lineal foot of pipe 30 inches internal diameter, and the metal $1\frac{1}{4}$ inches in thickness.

$$30 + 2{\cdot}5 = 32{\cdot}5 \text{ and } 32{\cdot}5 + 30 = 62{\cdot}5$$

then $62{\cdot}5 \times 2{\cdot}5 \times 2{\cdot}48 = 387{\cdot}5$ lbs., or 3 cwt. 1 qr., 23 lbs.

Diameters in inches, and weight in lbs. Avoirdupois, of Cast Iron Balls.

lbs.	inches.	lbs.	inches.		lbs.	inches.
1	$1\frac{7}{8}$ & $\frac{3}{32}$	22	$5\frac{7}{16}$		52	$7\frac{3}{16}$ & $\frac{1}{32}$
2	$2\frac{3}{8}$ & $\frac{3}{32}$	24	$5\frac{9}{16}$		54	$7\frac{5}{16}$ & $\frac{1}{32}$
3	$2\frac{3}{4}$ & $\frac{1}{32}$	26	$5\frac{3}{4}$	$\frac{1}{2}$ cwt.	56	$7\frac{3}{8}$ & $\frac{1}{32}$
4	$3\frac{3}{32}$	28	$5\frac{7}{8}$ & $\frac{1}{32}$		58	$7\frac{1}{2}$
5	$3\frac{5}{16}$	30	$6\frac{1}{32}$		60	$7\frac{1}{2}$ & $\frac{3}{32}$
6	$3\frac{1}{2}$	32	$6\frac{3}{16}$		62	$7\frac{5}{8}$ & $\frac{1}{32}$
7	$3\frac{3}{4}$	34	$6\frac{1}{4}$ & $\frac{1}{32}$		64	$7\frac{3}{4}$
8	$3\frac{7}{8}$	36	$6\frac{3}{8}$ & $\frac{1}{32}$		66	$7\frac{3}{4}$ & $\frac{3}{32}$
9	$4\frac{1}{32}$	38	$6\frac{1}{2}$ & $\frac{1}{32}$		68	$7\frac{7}{8}$ & $\frac{1}{32}$
10	$4\frac{3}{16}$	40	$6\frac{5}{8}$		70	$7\frac{7}{8}$ & $\frac{3}{32}$
12	$4\frac{7}{16}$	42	$6\frac{5}{8}$ & $\frac{3}{32}$	$\frac{3}{4}$ cwt.	84	$8\frac{3}{8}$ & $\frac{3}{32}$
14	$4\frac{11}{16}$	44	$6\frac{13}{16}$	1 cwt.	112	$9\frac{5}{16}$ & $\frac{1}{32}$
16	$4\frac{7}{8}$ & $\frac{1}{32}$	46	$6\frac{15}{16}$	5 ”	560	$15\frac{7}{8}$ & $\frac{1}{16}$
18	$5\frac{3}{32}$	48	$7\frac{1}{32}$	10 ”	1120	$20\frac{1}{16}$
20	$5\frac{1}{4}$ & $\frac{1}{32}$	50	$7\frac{1}{8}$ & $\frac{1}{32}$	1 ton.	2240	$25\frac{1}{4}$

Approximate Weights of a cylindrical inch of various Metals, in lbs. Avoirdupois.

Cast Iron	= ·2059	Copper, cast	= ·2462
Bar „	= ·2193	Brass, „	= ·24
Wrought „	= ·2215	Zinc, „	= ·2042
Steel, soft	= ·2207	Tin, „	= ·207
Lead, cast	= ·3259	Mercury at 60°	= ·3859

Ex. What will be the weight of a circular plate of cast iron 9 inches diameter and $\frac{3}{4}$ of an inch in thickness?

$$9^2 = 81 \times \cdot 75 = 60\cdot 75 \times \cdot 2059 = 12\cdot 5 \text{ lbs.}$$

Table of proportional dimensions for hexagonal nuts and bolt heads, with the number of threads per inch, in accordance with what is commonly called Whitworth's Table.

Diameter of bolts in inches	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$
Threads per inch	20	16	12	11	10	9
Breadth of nuts	$\frac{11}{16}$	$\frac{13}{16}$	1 in.	$1\frac{3}{16}$	$1\frac{3}{8}$	$1\frac{9}{16}$
Breadth over angles	$\frac{13}{16}$	$\frac{15}{16}$	$1\frac{1}{8}$	$1\frac{3}{8}$	$1\frac{5}{8}$	$1\frac{13}{16}$
Thickness of heads & nuts	$\frac{5}{16}$	$\frac{7}{16}$	$\frac{9}{16}$	$\frac{3}{4}$	$\frac{7}{8}$	1 in.
Diameter of bolts in inches	1 in.	$1\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{3}{8}$	$1\frac{1}{2}$	$1\frac{5}{8}$
Threads per inch	8	7	7	6	6	5
Breadth of nuts	$1\frac{3}{4}$	$1\frac{15}{16}$	$2\frac{1}{8}$	$2\frac{5}{16}$	$2\frac{1}{2}$	$2\frac{11}{16}$
Breadth over angles	2 in.	$2\frac{1}{4}$	$2\frac{1}{16}$	$2\frac{11}{16}$	$2\frac{7}{8}$	$3\frac{1}{8}$
Thickness of heads & nuts	$1\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{1}{16}$	$1\frac{9}{16}$	$1\frac{11}{16}$	$1\frac{13}{16}$
Diameter of bolts in inches	$1\frac{3}{4}$	$1\frac{7}{8}$	2 in.	$2\frac{1}{4}$	$2\frac{1}{2}$	3 in.
Threads per inch	5	$4\frac{1}{2}$	$4\frac{1}{2}$	4	4	$3\frac{1}{4}$
Breadth of nuts	$2\frac{7}{8}$	$3\frac{1}{16}$	$3\frac{1}{4}$	$3\frac{5}{8}$	4	—
Breadth over angles	$3\frac{5}{16}$	$3\frac{1}{2}$	$3\frac{3}{4}$	$4\frac{3}{16}$	$4\frac{5}{8}$	—
Thickness of heads & nuts	2 in.	$2\frac{1}{8}$	$2\frac{1}{4}$	$2\frac{1}{2}$	$2\frac{3}{4}$	—

Table exhibiting in successive order various properties of the principal metals.

Malleability.	Ductility.	Tenacity.
Gold	Gold	Wrought Iron
Silver	Silver	Wrt. Copper
Copper	Platinum	Platinum
Tin	Wrought Iron	Silver
Cadmium	Copper	Gold
Platinum	Zinc	Yellow Brass
Lead	Tin	Cast Iron
Zinc	Lead	Zinc
Wrought Iron	Nickel	Tin
Nickel	Palladium	Bismuth
Palladium	Cadmium	Lead

Properties of metals as materials of construction.

Ultimate cohesive strength of an inch square bar in Tons.		Relative strength to resist torsion Lead being 1.	Linear expansion from 32° to 212° Fahr.		Contracts in cooling from fluid to solid state.	
Cast steel	60	19·5	1 part in	842	·133	Parts of an inch per lineal foot.
Shear do.	57	17·0	"	890	—	
Wrt. iron	25	10·1	"	812	·137	
Gun metal	16	5·0	"	582	·220	
Wrt. copper ...	15	—		—	—	
Cast do. ...	8½	4·3	"	581	·193	
Yellow brass ...	8	4·6	"	584	·210	
Cast iron	7¾	9·0	"	900	·125	
Zinc............ ..	3¾	—	"	340	·329	
Cast tin	2	1·4	"	462	·278	
Bismuth	1½	—	"	719	·156	
Lead	¾	1·0	"	351	·319	

Melting, boiling, and freezing points of various bodies, in degrees of Fahrenheit.

		Degrees.
Platinum	melts at	3080
Nickel	„	2810
Cast Iron, average	„	2786
Gold, fine	„	2016
Copper	„	1996
Gun Metal	„	1900
Silver, pure	„	1873
Brass	„	1869
Antimony	„	810
Zinc	„	773
Lead	„	594
Bismuth	„	476
Tin 1 and Lead 4	„	460
Tin and Cadmium, each	„	442
Equal parts Tin and Bismuth	„	283
Sulphur	„	226
Bismuth 5, Tin 3, and Lead 2	„	214
Bismuth 8, Tin 3, and Lead 5	„	210
Bees-wax	„	151
Spermaceti	„	142
Bismuth 15, Lead 8, Tin 4, and Cadmium 3	„	138
Tallow	„	72
Mercury	boils at	660
Linseed Oil	„	600
Sulphuric Acid	„	590
Oil of Turpentine	„	560
Nitric Acid	„	242
Sea Water	„	213
Fresh Water	„	212
Ditto, in a vacuum	„	98
Olive Oil	freezes at	36
Fresh Water	„	32
Vinegar	„	28
Sea Water	„	27½
Wines, average	„	20
Turpentine	„	14
Sulphuric Acid	„	1

Equal parts Alcohol and Water freeze at 7° below Zero.
Alcohol 2 and Water 1 ... „ 11 „ „
Mercury ... ... freezes 39 „ „
Nitric Acid ... ... „ 45½ „ „

NOTE.—Red heat of a common fire equal about 1200° F., and white heat of a smith's forge 2900 F.

Proportions of Metals for the production of useful Alloys.

	Copper.	Tin.	Zinc.
Gun Metal	11	2	0
„	8	1	1
Bronze	4¼	1	0
„	9	1	0
Brass, hard	3¾	1	0
„ sheet	3	0	1
„ yellow	2	0	1
„ deep yellow	1	0	2
Bearings for Machinery	16	2½	½
Muntz's Metal	1½	0	1
Babbit's „ .... and 5 Regulus of Antimony	1	50	
Bell Metal, for large Bells............	8	2	0
„ „ small „	16	5	0
Spelter Solder for Brass	1	0	1
„ „ „ Copper and Iron	16	0	12
	Lead.		
Tinman's Solder	2	1	0
Plumber's „	1	1	0
Glazier's „	3	1	0

A metal that expands in cooling from the melted state:—Lead 9, Antimony 2, and Bismuth 1.

German Silver:—100 Copper, 60 Zinc, and 40 Nickel.

Mosaic Gold—16 Copper and 16½ Zinc.

Ordinary Type-metal.—15 Lead, 4 Antimony, and 1 Tin.

Britannia Metal:—50 Tin, 4 Antimony, 4 Bismuth, and 1 Copper.

Degrees of temperature necessary to effect the practical color on hardened steel, for the various purposes to which edge tools are applied.

Turning tools for metal	430° Fah.,	very pale straw color.
	to 450	A shade of darker yellow
Tools for Wood, Screw taps, &c.	470	A dark straw yellow.
	to 490	A dark straw yellow, approximating brown.
Hatchets, chipping chisels, and other percussive tools	500° to 520°	A brown yellow, or yellow slightly tinged with purple.
	to 530	Light purple.
Springs, &c.	550	Dark purple.
”	570	Dark blue.

Proportionate quantities of Lead and Tin that will when in a melted state produce the various degrees of color on hardened Steel by immersion.

1 lb. of Block Tin to each quantity of clean Lead.

	Degrees.		lbs.	oz.	
Light straw color	430	Fah.,	1	14	Lead.
Yellow	450	”	2	2	”
Dark straw yellow	470	”	2	8	”
Light brown	490	”	3	8	”
Brown yellow	500	”	4	12	”
Light purple	530	”	7	8	”
Dark purple	550	”	12	0	”
Dark blue	570	”	25	0	”

Change Wheels for Screw Cutting, the leading Screw of Lathe being ½ inch pitch.

			A	B	C	D	E
Number of Threads in Inch of Screw to be cut.	Number of Teeth in Wheel on Lathe Spindle.	Number of Teeth in Wheel on end of Leading Screw.	Number of Threads in Inch of Screw to be cut.	Number of Teeth in Wheel on Lathe Spindle.	Number of Teeth in Wheel in contact with Spindle Wheel.	Number of Teeth in Pinion in contact with Screw Wheel.	Number of Teeth in Wheel on end of Leading Screw.
1	80	40	* 8½	90	85	20	90
1¼	80	50	* 9	60	90	20	60
1½	80	60	* 9½	60	60	20	95
1¾	80	70	*10	60	75	20	80
2	60	60	*10½	50	70	20	75
2¼	80	90	*11	60	75	20	80
2½	80	100	*11½	60	115	20	60
2¾	80	110	*12	60	60	20	120
3	80	120	13	20	65	60	120
3¼	80	130	14	20	70	60	120
3¼	40	65	15	20	75	60	120
3½	80	140	16	20	80	60	120
3½	40	70	17	20	85	60	120
3¾	80	150	18	20	90	60	120
3¾	40	75	19	20	95	60	120
4	40	80	20	20	100	60	120
4¼	40	85	21	20	105	60	120
4½	40	90	22	20	110	60	120
4¾	40	95	23	20	115	60	120
5	40	100	24	65	120	20	130
5½	40	110	24	55	120	20	110
6	40	120	25	60	100	20	150
6½	40	130	25	30	100	20	75
6½	20	65	26	70	130	20	140
7	40	140	26	20	120	30	65
7	20	70	28	75	140	20	150
7½	40	150	30	70	140	20	150
7½	20	75	32	30	80	20	120
8	30	120	34	30	85	20	120
8½	20	85	36	30	90	20	120
9	20	90	38	30	95	20	120
9½	20	95	40	30	100	20	120
10	20	100	42	30	105	20	120
10½	20	105	44	30	110	20	120
11	20	110	46	30	115	20	120
11½	20	115	48	25	120	20	100
12	20	120	50	30	100	20	150

The Pitches in the preceding Table marked * are repeated for the convenience of those who may prefer using the compound series.

NOTE.—If the Leading Screw contains four threads to the inch ($\frac{1}{4}$ inch pitch), the screw to be cut will have double the number of threads given in the foregoing Table.

To calculate for the Change Wheels when any other pitch of leading screw is given or required—

Let A represent the number of threads to be cut per inch;

B, the number of teeth in wheel on lathe spindle;

C, the number of teeth in wheel in contact with spindle wheel;

D, the number of teeth in wheel in contact with leading screw wheel;

E, the number of teeth in wheel on end of leading screw; and

n, the pitch of leading screw per inch.

$$\text{Then, } \frac{A \times B \times D}{E \times n} = C.$$

$$\frac{A \times B \times C}{E \times n} = D.$$

$$\frac{C \times E \times n}{A \times D} = B.$$

$$\frac{A \times B \times D}{C \times n} = E.$$

Arithmetically thus:—

Let the leading screw equal $\frac{1}{2}$ inch pitch, or 2 threads per inch, and the screw to be cut $10\frac{1}{2}$ threads per inch.

Take any 3 of the screw cutting wheels that can be conveniently applied, say B of 50 teeth, E of 75, and D of 20, to find the number of teeth required in C.

$$\frac{10{\cdot}5 \times 50 \times 20}{75 \times 2} = \frac{10500}{150} = 70 \text{ teeth in C.}$$

To determine the number of teeth or pitch of small wheels, on the Manchester principle.

In this mode of finding the number of teeth for any wheel of a given diameter, or the diameter of a pitch circle to contain any required number of teeth, simplicity is the chief aim, by evasion of fractional parts in the calculation. To effect this, the division of the pitch circle is entirely disregarded, and the pitch or number of teeth is determined by whole numbers on the pitch circle's diameter, and called the diametral pitch, whereby to distinguish between that and the common or circular pitch. In the following table the circular pitches are merely notified, so as to give some idea of the size of the teeth, by which to select what might be best adapted in strength to any particular purpose required.

Table of Pitches.

Diametral pitch.	Circular pitch in decimals.	Circular pitch in fractions.	Diametral pitch.	Circular pitch in decimals.	Circular pitch in fractions.
3	1·047	1 & $\frac{1}{32}$ ins.	9	·349	$\frac{1}{4}$ & $\frac{3}{32}$
4	·785	$\frac{3}{4}$ & $\frac{1}{32}$	10	·314	$\frac{1}{4}$ & $\frac{1}{16}$
5	·628	$\frac{5}{8}$	12	·262	$\frac{1}{4}$
6	·524	$\frac{1}{2}$ inch	14	·224	$\frac{1}{8}$ & $\frac{3}{32}$
7	·449	$\frac{3}{8}$ & $\frac{1}{16}$	16	·196	$\frac{1}{8}$ & $\frac{1}{16}$
8	·393	$\frac{3}{8}$	20	·157	$\frac{1}{8}$ & $\frac{1}{32}$

1. To find what number of teeth any wheel of a given diameter of pitch circle will contain, or divide into, of a required pitch :—

Rule.—Multiply the diameter of the pitch circle in inches by the given diametral pitch, and the product is the number of teeth.

Ex. Required the number of teeth in a wheel of 15 inches, and of 6 pitch.

15 × 6 = 90 teeth of ½ inch circular pitch.

2. To determine the diameter of pitch circle to contain a given number of teeth of a given pitch:—

Rule.—Divide the given number of teeth by the required diametral pitch, and the quotient is the diameter of pitch circle.

Ex. What diameter of pitch circle is necessary for a wheel of 172 teeth and of 16 pitch?

172 ÷ 16 = 10·75 inches,—circular pitch = $\frac{3}{16}$ of an inch.

Table of approximate numbers by which to determine the diameter of any pitch circle for a toothed wheel when the pitch of teeth and number are given; also, to find what number of teeth of a given pitch any given diameter of pitch circle will divide into.

Pitch in inches.	To find the diameter.	To find the number of teeth.	Pitch in inches.	To find the diameter.	To find the number of teeth.
½	·1592	6·2832	2 ins.	·6366	1·5708
⅝	·1989	5·0266	2⅛	·6764	1·4773
¾	·2387	4·1888	2¼	·7135	1·3963
⅞	·2785	3·5901	2⅜	·7560	1·3240
1 inch	·3183	3·1416	2½	·7958	1·2566
1⅛	·3568	2·7926	2¾	·8754	1·1333
1¼	·3979	2·5132	3 ins.	·9547	1·0472
1⅜	·4377	2·2848	3¼	1·0345	·9667
1½	·4774	2·0944	3½	1·1141	·8976
1⅝	·5141	1·9264	4	1·2732	·7854
1¾	·5370	1·7952	5	1·5915	·6283
1⅞	·5937	1·6755	6	1·9095	·5236

Rule 1.—Multiply the numbers corresponding to the pitch in the columns 2 or 5, and the product is the diameter of pitch circle in inches.

Ex. Suppose a wheel of 128 teeth is required of 2⅛ pitch.

·6764 × 128 = 86·5792 or 86½ and $\frac{1}{16}$ inches the diameter.

Rule 2.—Multiply the numbers corresponding to the pitch in columns 3 or 6, and the product will show the number, plus or minus, that the circle will divide into at the given pitch.

Ex. A pitch circle is required to be divided into 1½ inch pitch, the diameter is 43½ inches; what will be the number of teeth?

2·0944 × 43·5 = 91·1 teeth, hence the circle is plus $\frac{1}{10}$th of the pitch towards another tooth.

The diameter of pitch circle being given, and also the number of teeth required,—To find the pitch into which it will divide.

Rule.—Multiply 3·1416 by the circle's diameter in inches, and divide the product by the number of teeth; the quotient is the pitch in inches.

Thus, suppose a pitch circle of 43½ inches to be divided into 91 teeth, what will be the pitch?

$$3{\cdot}1416 \times 43{\cdot}5 = \frac{136{\cdot}6596}{91} = 1{\cdot}501 \text{ inches, and}$$

such measurements can only be obtained from the decimal scale of inches, as annexed in the work.

Pitch of the Teeth of Wheels proportionate in strength to a given amount of Horses' Power nominally, at various velocities.

Pitch	Thickness	Breadth	Velocities at the Pitch Circles, in feet per minute, viz.,			
of Teeth in inches.			180	240	300	420
			Horses' Power.			
4	1·9	8	19	25·5	32	45
3½	1·6	7	14·75	19·5	24·5	34·25
3	1·4	6	11	14·5	18	25
2½	1·2	5	7·5	10	12·5	17·5
2	·95	4	4·75	6·25	8	11
1¾	·83	3·5	3·5	5	6·25	6·25
1½	·71	3	2·75	3·5	4·5	4·5
1¼	·59	2·5	2	2·5	3·125	3·5
1⅛	·53	2·25	1·5	2·25	2·5	2·8
1 inch	·48	2	1·2	1·6	2	2·5

Restrictions relative to Wheels and Pinions in working contact, that ought to be attended to.

1. When wheels drive pinions, let no pinion have less than 8 teeth, rather 11 or 12 if possibly convenient.

2. When pinions drive wheels, let no pinion have less than 6 teeth, rather 8 or 9.

3. The number of teeth in a wheel should be prime to the number of teeth in a pinion: that is, suppose a pinion to contain 9 teeth, and required to make 6 revolutions for 1 of the wheel; 6 times 9 = 54 teeth, and one added = 55 teeth in the wheel.

4. To increase or diminish velocity in a given proportion, and with the least quantity of wheel work, let the number of teeth on each pinion be to the number of teeth on its wheel as 1 to 6; that is, never let more than 6 teeth be in the wheel for 1 in the pinion.

Table of the Pitch Circles of Wheels, from

Number of Teeth.	Pitch of the Teeth in inches.																	
	½		⅝		¾		⅞		1 in.		1⅛		1¼		1⅜		1½	
	Diameter of Pitch Circle in feet and inches.																	
11	0	1¾	0	2⅛	0	2⅝	0	3	0	3½	0	4	0	4⅜	0	5	0	5⅜
12	0	1⅞	0	2⅜	0	2¾	0	3¼	0	3⅞	0	4⅜	0	4⅞	0	5⅜	0	5⅞
13	0	2	0	2½	0	3	0	3⅝	0	4⅛	0	4¾	0	5¼	0	5¾	0	6¼
14	0	2¼	0	2¾	0	3¼	0	3⅞	0	4½	0	5	0	5⅝	0	6¼	0	6¾
15	0	2⅜	0	2⅞	0	3½	0	4⅛	0	4⅞	0	5⅜	0	6	0	6⅝	0	7⅛
16	0	2½	0	3⅛	0	3¾	0	4⅜	0	5⅛	0	5¾	0	6⅜	0	7	0	7⅝
17	0	2¾	0	3⅜	0	4	0	4¾	0	5½	0	6⅛	0	6¾	0	7½	0	8⅛
18	0	2⅞	0	3½	0	4¼	0	5	0	5¾	0	6½	0	7⅛	0	8	0	8⅝
19	0	3	0	3¾	0	4½	0	5¼	0	6	0	6⅞	0	7½	0	8⅜	0	9⅛
20	0	3⅛	0	3⅞	0	4¾	0	5½	0	6⅜	0	7⅛	0	8	0	8⅞	0	9⅝
21	0	3¼	0	4⅛	0	5	0	5⅞	0	6¾	0	7½	0	8⅜	0	9¼	0	10
22	0	3½	0	4⅜	0	5¼	0	6⅛	0	7	0	7⅞	0	8¾	0	9⅝	0	10⅝
23	0	3⅝	0	4½	0	5½	0	6⅜	0	7⅜	0	8¼	0	9⅛	0	10	0	11
24	0	3¾	0	4¾	0	5¾	0	6⅝	0	7⅝	0	8⅝	0	9½	0	10½	0	11½
25	0	3⅞	0	4⅞	0	5⅞	0	6⅞	0	8	0	9	0	10	0	11	1	0
26	0	4⅛	0	5⅛	0	6⅛	0	7¼	0	8¼	0	9¼	0	10⅜	0	11½	1	0½
27	0	4¼	0	5⅜	0	6⅜	0	7½	0	8⅝	0	9⅝	0	10¾	0	11⅞	1	1
28	0	4⅜	0	5½	0	6⅝	0	7¾	0	9	0	10	0	11⅛	1	0¼	1	1¼
29	0	4⅝	0	5¾	0	6⅞	0	8	0	9¼	0	10⅜	0	11⅝	1	0¾	1	1⅞
30	0	4¾	0	5⅞	0	7⅛	0	8¼	0	9⅝	0	10¾	1	0	1	1⅛	1	2⅜
31	0	4⅞	0	6⅛	0	7⅜	0	8⅝	0	9⅞	0	11⅛	1	0⅜	1	1⅝	1	2⅞
32	0	5	0	6⅜	0	7⅝	0	8⅞	0	10¼	0	11½	1	0¾	1	2	1	3⅜
33	0	5¼	0	6½	0	7⅞	0	9⅛	0	10½	0	11⅞	1	1⅛	1	2½	1	3¾
34	0	5⅜	0	6¾	0	8⅛	0	9⅜	0	10⅞	1	0⅛	1	1⅝	1	3	1	4¼
35	0	5½	0	6⅞	0	8⅜	0	9¾	0	11⅛	1	0⅝	1	2	1	3⅜	1	4¾

11 *to* 150 *Teeth, of a given Pitch.*

Number of Teeth.	Pitch of the Teeth in inches.								
	1⅝	¾	1⅞	2 in.	2⅛	2¼	2½	2¾	3 in.
	Diameter of Pitch Circle in feet and inches.								
11	0 5¾	0 6¼	0 6⅝	0 7	0 7½	0 7⅞	0 8¾	0 9¾	0 10⅝
12	0 6⅜	0 6¾	0 7⅛	0 7⅝	0 8⅛	0 8⅝	0 9⅝	0 10⅝	0 11½
13	0 6⅞	0 7⅜	0 7⅞	0 8⅜	0 8⅞	0 9⅜	0 10⅜	0 11½	1 0½
14	0 7⅜	0 7⅞	0 8½	0 9	0 9½	0 10	0 11¼	1 0⅜	1 1⅜
15	0 7⅞	0 8½	0 9	0 9⅝	0 10¼	0 10¾	1 0	1 1¼	1 2⅜
16	0 8⅜	0 9	0 9⅝	0 10¼	0 10⅞	0 11½	1 0¾	1 2	1 3⅜
17	0 8⅞	0 9⅝	0 10¼	0 10⅞	0 11½	1 0¼	1 1½	1 2⅞	1 4¼
18	0 9⅜	0 10	0 10¾	0 11½	1 0¼	1 0⅞	1 2⅜	1 3¾	1 5¼
19	0 9⅞	0 10⅝	0 11⅜	1 0⅛	1 0⅞	1 1⅝	1 3⅛	1 4⅝	1 6¼
20	0 10⅜	0 11¼	1 0	1 0¾	1 1½	1 2⅜	1 4	1 5½	1 7⅛
21	0 11	0 11¾	1 0½	1 1½	1 2¼	1 3	1 4¾	1 6⅜	1 8⅛
22	0 11½	1 0⅜	1 1⅛	1 2	1 2⅞	1 3¾	1 5½	1 7¼	1 9
23	1 0	1 0⅞	1 1¾	1 2⅝	1 3½	1 4½	1 6⅜	1 8	1 10
24	1 0½	1 1½	1 2⅜	1 3⅜	1 4¼	1 5¼	1 7⅛	1 9	1 10⅞
25	1 1	1 2	1 2⅞	1 3⅞	1 4⅞	1 6	1 8	1 9⅞	1 11⅞
26	1 1½	1 2½	1 3½	1 4½	1 5½	1 6⅝	1 8¾	1 10¾	2 0⅞
27	1 2	1 3	1 4⅛	1 5¼	1 6¼	1 7⅜	1 9½	1 11⅝	2 1¾
28	1 2½	1 3⅝	1 4⅝	1 5¾	1 6⅞	1 8	1 10¼	2 0½	2 2¾
29	1 3	1 4⅛	1 5⅜	1 6½	1 7⅝	1 8¾	1 11⅛	2 1⅜	2 3¾
30	1 3½	1 4½	1 6	1 7⅛	1 8¼	1 9½	2 0	2 2¼	2 4⅝
31	1 4	1 5⅜	1 6½	1 7¾	1 9	1 10¼	2 0¾	2 3⅛	2 5⅝
32	1 4⅝	1 5⅞	1 7⅛	1 8⅜	1 9⅝	1 11	2 1½	2 4	2 6½
33	1 5⅛	1 6½	1 7¾	1 9	1 10⅜	1 11⅝	2 2¼	2 4⅞	2 7½
34	1 5⅝	1 7	1 8⅜	1 9⅝	1 11	2 0⅜	2 3	2 5¾	2 8½
35	1 6⅛	1 7½	1 9	1 10⅜	1 11¾	2 1	2 3⅞	2 6⅝	2 9½

Number of Teeth	Pitch of the Teeth in inches.								
	½	⅝	¾	⅞	1 in.	1⅛	1¼	1⅜	1½
	Diameter of Pitch Circle in feet and inches.								
36	0 5¾	0 7⅛	0 8⅝	0 10	0 11½	1 1	1 2⅜	1 3¾	1 5¼
37	0 5⅞	0 7¼	0 8⅞	0 10¼	0 11¾	1 1¼	1 2¾	1 4¼	1 5⅝
38	0 6	0 7½	0 9⅛	0 10½	1 0⅛	1 1⅝	1 3¼	1 4⅝	1 6¼
39	0 6¼	0 7¾	0 9⅜	0 10⅞	1 0⅜	1 2	1 3½	1 5	1 6⅝
40	0 6⅜	0 7⅞	0 9⅝	0 11⅛	1 0¾	1 2⅜	1 4	1 5½	1 7⅛
41	0 6½	0 8⅛	0 9⅞	0 11⅜	1 1	1 2¾	1 4⅜	1 6	1 7⅝
42	0 6⅝	0 8¼	0 10⅛	0 11⅝	1 1⅜	1 3	1 4¾	1 6⅜	1 8
43	0 6¾	0 8½	0 10⅜	0 11⅞	1 1⅝	1 3½	1 5⅛	1 6⅞	1 8⅝
44	0 7	0 8¾	0 10½	1 0¼	1 2	1 3¾	1 5⅝	1 7¼	1 9
45	0 7⅛	0 8⅞	0 10¾	1 0½	1 2⅜	1 4⅛	1 6	1 7¾	1 9½
46	0 7¼	0 9⅛	0 10⅞	1 0¾	1 2⅝	1 4½	1 6⅜	1 8⅛	1 10
47	0 7½	0 9¼	0 11¼	1 1	1 2⅞	1 4⅞	1 6¾	1 8⅝	1 10½
48	0 7⅝	0 9½	0 11⅜	1 1¼	1 3¼	1 5¼	1 7⅛	1 9	1 11
49	0 7¾	0 9¾	0 11⅝	1 1⅝	1 3½	1 5⅝	1 7½	1 9½	1 11⅜
50	0 7⅞	0 9⅞	0 11⅞	1 1⅞	1 3⅞	1 6	1 8	1 9⅞	2 0
51	0 8⅛	0 10⅛	1 0⅛	1 2¼	1 4¼	1 6¼	1 8⅜	1 10⅜	2 0⅜
52	0 8¼	0 10¼	1 0⅜	1 2½	1 4½	1 6⅝	1 8¾	1 10¾	2 0⅞
53	0 8⅜	0 10½	1 0⅝	1 2¾	1 4⅞	1 6⅞	1 9⅛	1 11¼	2 1¼
54	0 8½	0 10¾	1 0⅞	1 3	1 5⅛	1 7⅜	1 9½	1 11⅝	2 1⅜
55	0 8¾	0 10⅞	1 1⅛	1 3¼	1 5½	1 7¾	1 9⅞	2 0	2 2¼
56	0 8⅞	0 11⅛	1 1⅜	1 3½	1 5⅞	1 8⅛	1 10¼	2 0½	2 2¾
57	0 9	0 11¼	1 1½	1 3⅞	1 6⅛	1 8½	1 10⅝	2 0⅞	2 3¼
58	0 9¼	0 11½	1 1¾	1 4⅛	1 6¾	1 8¾	1 11	2 1⅜	2 3⅝
59	0 9⅜	0 11⅝	1 2	1 4⅜	1 7⅛	1 9⅛	1 11½	2 1⅞	2 4⅛
60	0 9½	0 11⅞	1 2¼	1 4¾	1 7½	1 9⅜	1 11⅞	2 2¼	2 4⅝
61	0 9¾	1 0⅛	1 2½	1 5	1 7⅛	1 9⅞	2 0¼	2 2¾	2 5⅛
62	0 9⅞	1 0¼	1 2¾	1 5¼	1 7¾	1 10¼	2 0⅝	2 3⅛	2 5⅝
63	0 10	1 0½	1 3	1 5½	1 8	1 10½	2 1	2 3½	2 6
64	0 10⅛	1 0¾	1 3¼	1 5¾	1 8⅜	1 10⅞	2 1½	2 4	2 6½
65	0 10¼	1 0⅞	1 3½	1 6⅛	1 8⅝	1 11¼	2 1⅞	2 4½	2 7

Number of Teeth.	Pitch of the Teeth in inches.								
	1⅝	1¾	1⅞	2 in.	2⅛	2¼	2½	2¾	3 in.
	Diameter of Pitch Circle in feet and inches.								
36	1 6⅝	1 8	1 9½	1 10⅞	2 0⅜	2 2	2 4⅝	2 7½	2 10⅜
37	1 7¼	1 8⅝	1 10	1 11½	2 1	2 2½	2 5½	2 8⅜	2 11⅜
38	1 7⅝	1 9¼	1 10¾	2 0¼	2 1¾	2 3¼	2 6¼	2 9¼	3 0¼
39	1 8¼	1 9¾	1 11⅜	2 0⅞	2 2⅜	2 4	2 7	2 10⅛	3 1¼
40	1 8¾	1 10⅜	1 11⅞	2 1½	2 3	2 4⅝	2 7⅞	2 10¾	3 2¼
41	1 9¼	1 10⅞	2 0½	2 2⅛	2 3¾	2 5⅜	2 8⅝	2 11⅞	3 3⅛
42	1 9¾	1 11½	2 1	2 2¾	2 4½	2 6	2 9⅜	3 0¾	3 4⅛
43	1 10¼	2 0	2 1⅝	2 3⅜	2 5	2 6¾	2 10¼	3 1⅝	3 5
44	1 10¾	2 0½	2 2¼	2 4	2 5¾	2 7½	2 11	3 2½	3 6
45	1 11⅜	2 1	2 2⅞	2 4⅝	2 6½	2 8¼	2 11¾	3 3⅜	3 7
46	1 11⅞	2 1⅝	2 3½	2 5¼	2 7⅛	2 9	3 0⅝	3 4¼	3 7⅞
47	2 0⅜	2 1⅞	2 4	2 6	2 7⅞	2 9⅝	3 1⅜	3 5⅛	3 8⅞
48	2 0⅞	2 2¾	2 4⅝	2 6½	2 8½	2 10⅜	3 2¼	3 6	3 9⅞
49	2 1⅜	2 3⅜	2 5¼	2 7¼	2 9⅛	2 11	3 3	3 6⅞	3 10⅞
50	2 1⅞	2 3⅞	2 5⅞	2 7⅞	2 9¾	2 11¾	3 3¾	3 7¾	3 11¾
51	2 2⅜	2 4½	2 6½	2 8½	2 10½	3 0½	3 4½	3 8⅝	4 0¾
52	2 2⅞	2 4⅞	2 7⅛	2 9⅛	2 11⅛	3 1¼	3 5⅜	3 9½	4 1⅝
53	2 3⅜	2 5⅝	2 7⅝	2 9¾	2 11⅞	3 2	3 6¼	3 10½	4 2⅝
54	2 3⅞	2 6	2 8¼	2 10⅜	3 0½	3 2⅝	3 7	3 11	4 3½
55	2 4½	2 6⅝	2 8⅞	2 11	3 1¼	3 3½	3 7¾	4 0⅛	4 4½
56	2 4⅞	2 7⅛	2 9⅜	2 11⅝	3 1⅞	3 4⅛	3 8½	4 1	4 5½
57	2 5¼	2 7¾	2 10	3 0¼	3 2½	3 4⅞	3 9⅜	4 1⅞	4 6⅜
58	2 6	2 8¼	2 10⅝	3 0⅞	3 3¼	3 5½	3 10⅛	4 2¾	4 7⅜
59	2 6½	2 8⅞	2 11¼	3 1½	3 4	3 6¼	3 11⅛	4 3⅝	4 8⅜
60	2 7	2 9⅜	2 11¾	3 2¼	3 4⅝	3 7	3 11¾	4 4½	4 9¼
61	2 7½	2 10	3 0⅜	3 2⅞	3 5¼	3 7¾	4 0½	4 5⅜	4 10¼
62	2 8	2 10½	3 1	3 3½	3 6	3 8½	4 1⅜	4 6¼	4 11¼
63	2 8⅝	2 11	3 1⅝	3 4⅛	3 6⅝	3 9⅛	4 2⅛	4 7⅛	5 0⅛
64	2 9⅛	2 11⅝	3 2¼	3 4¾	3 7¼	3 9⅞	4 3	4 8	5 1⅛
65	2 9⅝	3 0¼	3 2⅞	3 5⅜	3 8	3 10½	4 3¾	4 8⅞	5 2

Number of Teeth.	Pitch of the Teeth in inches.								
	½	⅝	¾	⅞	1 in.	1⅛	1¼	1⅜	1½
	Diameter of Pitch Circle in feet and inches.								
66	0 10½	1 1⅛	1 3¾	1 6⅜	1 9	1 11⅝	2 2¼	2 4⅞	2 7½
67	0 10⅝	1 1¼	1 4	1 6⅝	1 9⅜	2 0	2 2⅝	2 5¼	2 8
68	0 10¾	1 1½	1 4¼	1 6⅞	1 9⅝	2 0⅜	2 3	2 5¾	2 8½
69	0 10⅞	1 1¾	1 4½	1 7¼	1 9⅞	2 0¾	2 3½	2 6¼	2 8⅞
70	0 11⅛	1 1⅞	1 4¾	1 7½	1 10¼	2 1	2 3⅞	2 6⅝	2 9⅜
71	0 11¼	1 2⅛	1 4⅞	1 7¾	1 10⅝	2 1⅜	2 4¼	2 7	2 9⅞
72	0 11½	1 2¼	1 5⅛	1 8	1 10⅞	2 1¾	2 4⅝	2 7½	2 10⅜
73	0 11⅝	1 2½	1 5⅜	1 8¼	1 11¼	2 2⅛	2 5	2 8	2 10⅞
74	0 11¾	1 2¾	1 5⅝	1 8½	1 11½	2 2½	2 5½	2 8⅜	2 11⅜
75	0 11⅞	1 2⅞	1 5⅞	1 8⅞	1 11⅞	2 2⅞	2 5⅞	2 8⅞	2 11⅞
76	1 0	1 3⅛	1 6⅛	1 9⅛	2 0⅛	2 3¼	2 6¼	2 9¼	3 0¼
77	1 0¼	1 3¼	1 6⅜	1 9½	2 0½	2 3½	2 6⅝	2 9¾	3 0¾
78	1 0⅜	1 3½	1 6⅝	1 9¾	2 0⅞	2 3⅞	2 7	2 10⅛	3 1¼
79	1 0½	1 3¾	1 6⅞	1 10	2 1⅛	2 4⅛	2 7⅜	2 10½	3 1¾
80	1 0¾	1 3⅞	1 7	1 10¼	2 1½	2 4⅝	2 7¾	2 11	3 2¼
81	1 0⅞	1 4⅛	1 7¼	1 10½	2 1¾	2 5	2 8¼	2 11½	3 2⅝
82	1 1	1 4¼	1 7½	1 10⅞	2 2⅛	2 5⅜	2 8⅝	2 11⅞	3 3⅛
83	1 1⅛	1 4½	1 7¾	1 11⅛	2 2⅜	2 5¾	2 9	3 0⅜	3 3⅝
84	1 1⅜	1 4¾	1 8	1 11⅜	2 2¾	2 6	2 9⅜	3 0¾	3 4
85	1 1½	1 4⅞	1 8¼	1 11⅝	2 3	2 6⅜	2 9¾	3 1¼	3 4½
86	1 1⅝	1 5	1 8½	1 11⅞	2 3⅜	2 6¾	2 10¼	3 1⅝	3 5¼
87	1 1⅞	1 5¼	1 8¾	2 0¼	2 3⅝	2 7⅛	2 10⅝	3 2	3 5½
88	1 2	1 5½	1 9	2 0½	2 4	2 7½	2 11	3 2½	3 6
89	1 2⅛	1 5⅝	1 9¼	2 0¾	2 4⅜	2 7⅞	2 11⅜	3 2⅞	3 6½
90	1 2¼	1 5⅞	1 9½	2 1	2 4⅝	2 8¼	2 11¾	3 3¼	3 7
91	1 2½	1 6	1 9¾	2 1¼	2 4⅞	2 8½	3 0¼	3 3⅞	3 7½
92	1 2⅝	1 6¼	1 9⅞	2 1⅝	2 5¼	2 8⅞	3 0⅝	3 4¼	3 7⅞
93	1 2¾	1 6½	1 10⅛	2 1⅞	2 5⅝	2 9¼	3 1	3 4¾	3 8⅜
94	1 2⅞	1 6⅝	1 10⅜	2 2⅛	2 5⅞	2 9⅝	3 1⅜	3 5⅛	3 8⅞
95	1 3⅛	1 6⅞	1 10⅝	2 2⅜	2 6¼	2 10	3 1¾	3 5½	3 9⅜

Number of Teeth.	Pitch of the Teeth in inches.								
	1⅝	1¾	1⅞	2 in.	2⅛	2¼	2½	2¾	3 in.
	Diameter of Pitch Circle in feet ard inches.								
66	2 10⅛	3 0⅞	3 3⅜	3 6	3 8⅝	3 11¼	4 4½	4 9¾	5 3
67	2 10⅝	3 1⅜	3 4	3 6⅝	3 9⅜	4 0	4 5⅜	4 10⅝	5 4
68	2 11⅛	3 1¾	3 4⅝	3 7¼	3 10	4 0¾	4 6⅛	4 11½	5 5
69	2 11¾	3 2⅜	3 5⅛	3 7⅞	3 10⅝	4 1½	4 7	5 0⅜	5 6
70	3 0¼	3 3	3 5¾	3 8½	3 11⅜	4 2⅛	4 7¾	5 1¼	5 6⅞
71	3 0¾	3 3½	3 6⅜	3 9¼	4 0	4 2⅞	4 8½	5 2⅛	5 7¾
72	3 1¼	3 4⅛	3 6¾	3 9⅞	4 0¾	4 3½	4 9¼	5 3	5 8¾
73	3 1¾	3 4⅝	3 7½	3 10½	4 1⅜	4 4¼	4 10	5 3⅞	5 9¾
74	3 2¼	3 5¼	3 7⅞	3 11⅛	4 2	4 5	4 10⅞	5 4¾	5 10⅝
75	3 2¾	3 5¾	3 8¾	3 11¾	4 2¾	4 5¾	4 11¾	5 5⅝	5 11⅝
76	3 3¼	3 6⅜	3 9⅜	4 0⅜	4 3½	4 6½	5 0½	5 6½	6 0½
77	3 3⅞	3 6⅞	3 9⅞	4 1	4 4	4 7⅛	5 1¼	5 7⅜	6 1½
78	3 4⅜	3 7½	3 10⅝	4 1⅝	4 4¾	4 7⅞	5 2	5 8¼	6 2½
79	3 4⅞	3 8	3 11⅛	4 2¼	4 5½	4 8⅝	5 2⅞	5 9⅛	6 3½
80	3 5⅜	3 8½	3 11¾	4 3	4 6⅛	4 9¼	5 3⅝	5 10	6 4⅜
81	3 5⅞	3 9⅛	4 0⅜	4 3½	4 6⅞	4 10	5 4½	5 10⅞	6 5⅜
82	3 6⅜	3 9⅝	4 0⅞	4 4¼	4 7½	4 10¾	5 5¼	5 11¾	6 6⅜
83	3 6⅞	3 10¼	4 1½	4 4⅞	4 8⅛	4 11½	5 6	6 0⅝	6 7¼
84	3 7½	3 10¾	4 2⅛	4 5½	4 8⅞	5 0⅛	5 6⅞	6 1½	6 8¼
85	3 7⅞	3 11¼	4 2¾	4 6⅛	4 9½	5 0⅞	5 7⅝	6 2⅜	6 9⅛
86	3 8½	3 11⅞	4 3¼	4 6¾	4 10⅛	5 1⅝	5 8½	6 3¼	6 10½
87	3 9	4 0½	4 3⅞	4 7⅜	4 10⅞	5 2¼	5 9¼	6 4⅛	6 11
88	3 9½	4 1	4 4½	4 8	4 11½	5 3	5 10	6 5	7 0
89	3 10	4 1⅝	4 5⅛	4 8⅝	5 0¼	5 3¾	5 10¾	6 5⅞	7 1
90	3 10½	4 2⅛	4 5¾	4 9¼	5 0⅞	5 4¼	5 11⅝	6 6¾	7 2
91	3 11	4 2¾	4 6¼	4 9⅞	5 1½	5 5⅛	6 0⅜	6 7⅝	7 2⅞
92	3 11⅝	4 3¼	4 7	4 10½	5 2¼	5 5⅞	6 1	6 8½	7 3⅞
93	4 0⅛	4 3⅞	4 7½	4 11¼	5 2⅞	5 6⅝	6 2	6 9⅜	7 4⅞
94	4 0⅝	4 4⅜	4 8⅛	4 11¾	5 3⅝	5 7⅜	6 2¾	6 10¼	7 5¾
95	4 1⅛	4 4⅞	4 8¾	5 0½	5 4¼	5 8	6 3½	6 11⅛	7 6¾

Number of Teeth.	Pitch of the Teeth in inches.																	
	½		⅝		¾		⅞		1 in.		1⅛		1¼		1⅜		1½	
	Diameter of Pitch Circle in feet and inches.																	
96	1	3¼	1	7	1	10⅞	2	2¾	2	6½	2	10⅜	3	2⅛	3	6	3	9¾
97	1	3⅜	1	7¼	1	11⅛	2	3	2	6⅞	2	10¾	3	2⅝	3	6½	3	10¼
98	1	3½	1	7½	1	11⅜	2	3¼	2	7⅛	2	11	3	3	3	6⅞	3	10¾
99	1	3¾	1	7⅝	1	11⅝	2	3½	2	7½	2	11⅜	3	3⅜	3	7⅜	3	11¼
100	1	3⅞	1	7⅞	1	11⅞	2	3¾	2	7⅞	2	11⅞	3	3¾	3	7¾	3	11¾
101	1	4	1	8	2	0⅛	2	4⅛	2	8¼	3	0⅛	3	4⅛	3	8¼	4	0¼
102	1	4¼	1	8¼	2	0¼	2	4⅜	2	8½	3	0½	3	4½	3	8⅝	4	0⅝
103	1	4⅜	1	8½	2	0½	2	4⅝	2	8¾	3	0¾	3	4⅞	3	9	4	1⅛
104	1	4½	1	8⅝	2	0¾	2	4⅞	2	9⅛	3	1⅛	3	5⅜	3	9½	4	1⅝
105	1	4¾	1	8⅞	2	1	2	5¼	2	9½	3	1½	3	5¾	3	9⅞	4	2⅛
106	1	4⅞	1	9	2	1¼	2	5½	2	9¾	3	1⅞	3	6⅛	3	10¼	4	2⅝
107	1	5	1	9¼	2	1½	2	5¾	2	10⅛	3	2⅛	3	6½	3	10⅞	4	3
108	1	5⅛	1	9½	2	1¾	2	6	2	10⅜	3	2⅝	3	6⅞	3	11¼	4	3½
109	1	5¼	1	9⅝	2	2	2	6⅜	2	10⅝	3	2⅞	3	7⅜	3	11¾	4	4
110	1	5½	1	9⅞	2	2¼	2	6⅝	2	11	3	3¼	3	7¾	4	0⅛	4	4½
111	1	5⅝	1	10	2	2½	2	6⅞	2	11¼	3	3½	3	8⅛	4	0½	4	5
112	1	5¾	1	10¼	2	2¾	2	7⅛	2	11⅝	3	3⅞	3	8½	4	1	4	5½
113	1	5⅞	1	10½	2	3	2	7½	2	11⅞	3	4¼	3	8⅞	4	1½	4	6
114	1	6⅛	1	10⅝	2	3¼	2	7¾	3	0¼	3	4⅝	3	9⅜	4	1⅞	4	6½
115	1	6¼	1	10⅞	2	3½	2	8	3	0⅝	3	5	3	9¾	4	2¼	4	7
116	1	6⅜	1	11	2	3⅝	2	8¼	3	0⅞	3	5⅜	3	10⅛	4	2¾	4	7⅜
117	1	6⅝	1	11¼	2	3⅞	2	8½	3	1¼	3	5¾	3	10½	4	3¼	4	7⅞
118	1	6¾	1	11½	2	4⅛	2	8⅞	3	1½	3	6⅛	3	10⅞	4	3⅝	4	8¼
119	1	6⅞	1	11⅝	2	4⅜	2	9⅛	3	1⅞	3	6½	3	11⅜	4	4	4	8¾
120	1	7⅛	1	11⅞	2	4⅝	2	9½	3	2¼	3	6⅞	3	11¾	4	4½	4	9¼
121	1	7¼	2	0	2	4⅞	2	9¾	3	2½	3	7⅛	4	0⅛	4	5	4	9¾
122	1	7⅜	2	0¼	2	5⅛	2	9⅞	3	2⅞	3	7½	4	0½	4	5⅜	4	10¼
123	1	7½	2	0½	2	5¼	2	10¼	3	3⅛	3	7⅞	4	0⅞	4	5⅞	4	10¾
124	1	7¾	2	0⅝	2	5½	2	10½	3	3½	3	8¼	4	1¼	4	6¼	4	11⅛
125	1	7⅞	2	0⅞	2	5⅞	2	10¾	3	3¾	3	8½	4	1¾	4	6¾	4	11⅝

Number of Teeth.	Pitch of the Teeth in inches.								
	1⅝	1¾	1⅞	2 in.	2⅛	2¼	2½	2¾	3 in.
	Diameter of Pitch Circle in feet and inches.								
96	4 1⅝	4 5½	4 9⅜	5 1⅛	5 5	5 8¾	6 4⅜	7 0	7 7⅝
97	4 2⅛	4 6	4 10	5 1¾	5 5⅝	5 9½	6 5¼	7 0⅞	7 8⅝
98	4 2⅝	4 6½	4 10½	5 2⅜	5 6¼	5 10⅛	6 6	7 1¾	7 9½
99	4 3¼	4 7⅛	4 11	5 3	5 7	5 11	6 6¾	7 2⅝	7 10½
100	4 3¾	4 7¾	4 11⅝	5 3⅝	5 7⅝	5 11⅝	6 7½	7 3⅝	7 11½
101	4 4¼	4 8¼	5 0¼	5 4¼	5 8¼	6 0¼	6 8⅜	7 4⅜	8 0½
102	4 4¾	4 8⅞	5 1	5 5	5 9	6 1	6 9⅛	7 5¼	8 1⅜
103	4 5	4 9⅜	5 1½	5 5½	5 9⅝	6 1½	6 10	7 6⅛	8 2¼
104	4 5½	4 10	5 1¾	5 6¼	5 10¼	6 2¼	6 10¾	7 7	8 3¼
105	4 6	4 10½	5 2⅜	5 6¾	5 11	6 3	6 11½	7 7⅞	8 4¼
106	4 6½	4 11	5 2⅞	5 7½	5 11⅝	6 3⅝	7 0¼	7 8¾	8 5⅛
107	4 7	4 11½	5 3½	5 8⅛	6 0⅜	6 4¼	7 1⅛	7 9⅝	8 6⅛
108	4 7½	5 0⅛	5 4⅛	5 8¾	6 1	6 5	7 2	7 10½	8 7⅛
109	4 8	5 0¾	5 4¾	5 9⅜	6 1¾	6 5¾	7 2¾	7 11⅜	8 8
110	4 8½	5 1¼	5 5¼	5 10	6 2⅜	6 6½	7 3½	8 0¼	8 9
111	4 9	5 1⅞	5 5⅞	5 10⅝	6 3	6 7⅛	7 4¼	8 1⅛	8 10
112	4 9½	5 2⅜	5 6½	5 11¼	6 3¾	6 8	7 5⅛	8 2	8 10⅞
113	4 10	5 3	5 7	6 0	6 4⅜	6 8⅝	7 6	8 3	8 11⅞
114	4 10½	5 3½	5 7⅝	6 0½	6 5⅛	6 9¼	7 6¾	8 3¾	9 0¾
115	4 11⅛	5 4	5 8¼	6 1¼	6 5¾	6 10	7 7½	8 4⅝	9 1¾
116	4 11⅝	5 4⅝	5 8⅞	6 1¾	6 6½	6 10¾	7 8¼	8 5½	9 2¾
117	5 0⅛	5 5⅛	5 9½	6 2½	6 7⅛	6 11½	7 9⅛	8 6⅜	9 3⅝
118	5 0⅝	5 5¾	5 10	6 3⅛	6 7¾	7 0⅛	7 10	8 7¼	9 4⅝
119	5 1⅛	5 6¼	5 10⅝	6 3¾	6 8½	7 1	7 10¾	8 8⅛	9 5½
120	5 1¾	5 6¾	5 11¼	6 4⅜	6 9⅛	7 1⅝	7 11½	8 9	9 6½
121	5 2¼	5 7⅜	5 11⅞	6 5	6 9¾	7 2¼	8 0¼	8 9⅞	9 7½
122	5 2¾	5 8	6 0½	6 5⅝	6 10½	7 3	8 1	8 10¾	9 8½
123	5 3¼	5 8½	6 1	6 6¼	6 11⅛	7 3¾	8 1⅞	8 11⅝	9 9⅜
124	5 3¾	5 9	6 1⅝	6 7	6 11⅞	7 4½	8 2⅝	9 0½	9 10⅜
125	5 4¼	5 9⅝	6 2¼	6 7½	7 0½	7 5⅛	8 3½	9 1⅜	9 11¼

Number of Teeth.	Pitch of the Teeth in inches.																	
	½		⅝		¾		⅞		1 in.		1⅛		1¼		1⅜		1½	
	Diameter of Pitch Circle in feet and inches.																	
126	1	8	2	1	2	6	2	11	3	4⅛	3	8⅞	4	2⅛	4	7⅛	5	0⅛
127	1	8⅛	2	1¼	2	6¼	2	11⅜	3	4½	3	9¼	4	2½	4	7½	5	0⅝
128	1	8⅜	2	1⅜	2	6½	2	11⅝	3	4¾	3	9⅝	4	2⅞	4	8	5	1⅛
129	1	8½	2	1⅝	2	6¾	2	11⅞	3	5	3	10	4	3¼	4	8½	5	1½
130	1	8⅝	2	1⅞	2	7	3	0¼	3	5⅜	3	10⅜	4	3¾	4	9	5	2
131	1	8¾	2	2	2	7¼	3	0½	3	5⅝	3	10¾	4	4⅛	4	9⅜	5	2½
132	1	9	2	2¼	2	7½	3	0¾	3	6	3	11	4	4½	4	9¾	5	3
133	1	9⅛	2	2½	2	7¾	3	1	3	6¼	3	11½	4	4⅞	4	10¼	5	3½
134	1	9¼	2	2⅝	2	7⅞	3	1¼	3	6⅝	3	11⅞	4	5¼	4	10⅝	5	4
135	1	9½	2	2⅞	2	8¼	3	1½	3	6⅞	4	0⅛	4	5¾	4	11	5	4½
136	1	9⅝	2	3	2	8½	3	1⅞	3	7¼	4	0½	4	6⅛	4	11½	5	5
137	1	9¾	2	3¼	2	8¾	3	2⅛	3	7⅝	4	0⅞	4	6½	5	0	5	5⅜
138	1	9⅞	2	3½	2	9	3	2⅜	3	7⅞	4	1¼	4	6⅞	5	0⅜	5	5⅞
139	1	10⅛	2	3⅝	2	9⅛	3	2¾	3	8¼	4	1⅝	4	7¼	5	0⅞	5	6¼
140	1	10¼	2	3⅞	2	9⅜	3	3	3	8½	4	1⅞	4	7¾	5	1¼	5	6¾
141	1	10½	2	4	2	9⅝	3	3¼	3	8⅞	4	2¼	4	8⅛	5	1¾	5	7¼
142	1	10⅝	2	4¼	2	9⅞	3	3½	3	9⅛	4	2⅝	4	8½	5	2⅛	5	7¾
143	1	10¾	2	4½	2	10⅛	3	3⅞	3	9½	4	3	4	8⅞	5	2½	5	8¼
144	1	10⅞	2	4⅝	2	10⅜	3	4⅛	3	9¾	4	3⅜	4	9¼	5	3	5	8¾
145	1	11	2	4⅞	2	10⅝	3	4⅜	3	10⅛	4	3¾	4	9⅝	5	3½	5	9¼
146	1	11¼	2	5	2	10¾	3	4⅝	3	10½	4	4	4	10	5	4	5	9¾
147	1	11⅜	2	5¼	2	11	3	4⅞	3	10¾	4	4¼	4	10½	5	4⅜	5	10⅛
148	1	11½	2	5½	2	11¼	3	5¼	3	11⅛	4	4⅞	4	10⅞	5	4¾	5	10⅝
149	1	11¾	2	5⅝	2	11½	3	5½	3	11½	4	5⅜	4	11¼	5	5¼	5	11⅛
150	1	11⅞	2	5⅞	2	11¾	3	5¾	3	11¾	4	5½	4	11⅝	5	5⅝	5	11⅝

Number of Teeth.	Pitch of the Teeth in inches.								
	1⅝	1¾	1⅞	2 in.	2⅛	2¼	2½	2¾	3 in.
	Diameter of Pitch Circle in feet and inches.								
126	5 4¾	5 10⅛	6 2¾	6 8¼	7 1¼	7 6	8 4¼	9 2¼	10 0¼
127	5 5¼	5 10¾	6 3⅜	6 8¾	7 2	7 6⅝	8 5	9 3⅛	10 1¼
128	5 5⅞	5 11¼	6 4	6 9½	7 2½	7 7¼	8 5⅞	9 4	10 2¼
129	5 6⅜	5 11⅞	6 4½	6 10⅛	7 3¼	7 8	8 6⅝	9 4⅞	10 3⅛
130	5 6⅞	6 0⅜	6 5⅛	6 10¾	7 4	7 8¾	8 7½	9 5¾	10 4⅛
131	5 7⅜	6 1	6 5¾	6 11⅜	7 4½	7 9½	8 8¼	9 6⅝	10 5
132	5 7⅞	6 1½	6 6⅜	7 0	7 5⅛	7 10⅛	8 9	9 7½	10 6
133	5 8⅜	6 2	6 7	7 0⅝	7 6	7 10⅞	8 9¾	9 8⅜	10 7
134	5 8⅞	6 2⅝	6 7½	7 1¼	7 6⅝	7 11½	8 10⅝	9 9¼	10 8
135	5 9⅜	6 3⅛	6 8⅛	7 2	7 7¼	8 0¼	8 11⅜	9 10⅛	10 8⅞
136	5 10	6 3¾	6 8¾	7 2⅝	7 8	8 1	9 0¼	9 11	10 9¾
137	5 10½	6 4¼	6 9¼	7 3¼	7 8⅝	8 1¾	9 1	10 0	10 10¾
138	5 11	6 4¾	6 10	7 3⅞	7 9¼	8 2½	9 1¾	10 0⅞	10 11¾
139	5 11½	6 5½	6 10½	7 4½	7 10	8 3⅜	9 2⅝	10 1⅝	11 0⅝
140	6 0	6 6	6 11⅛	7 5⅛	7 10⅝	8 3⅞	9 3⅜	10 2½	11 1⅝
141	6 0½	6 6½	6 11¾	7 5¾	7 11⅜	8 4½	9 4¼	10 3⅜	11 2⅝
142	6 1	6 7	7 0¼	7 6¾	8 0	8 5¼	9 5	10 4¼	11 3½
143	6 1½	6 7⅝	7 0⅞	7 7	8 0¾	8 6	9 5¾	10 5⅛	11 4½
144	6 2	6 8¼	7 1½	7 7⅝	8 1⅜	8 6¾	9 6	10 6	11 5½
145	6 2½	6 8¾	7 2	7 8¼	8 2	8 7½	9 7⅜	10 6⅞	11 6½
146	6 3	6 9¼	7 2⅝	7 9	8 2¾	8 8⅛	9 8⅛	10 7¾	11 7⅜
147	6 3½	6 9⅞	7 3¼	7 9½	8 3⅜	8 3⅞	9 9	10 8⅝	11 8¼
148	6 4	6 10½	7 3⅞	7 10⅛	8 4⅛	8 9⅜	9 9¾	10 9½	11 9¼
149	6 4½	6 11	7 4½	7 10¾	8 4⅞	8 10¼	9 10½	10 10⅜	11 10¼
150	6 5⅛	6 11½	7 5	7 11½	8 5½	8 11	9 11⅜	10 11¼	11 11¼

Number of Teeth.	Pitch of the Teeth in inches.								
	½	⅝	¾	⅞	1 in.	1⅛	1¼	1⅜	1½
	Diameter of Pitch Circle in feet and inches.								
126	1 8	2 1	2 6	2 11	3 4⅛	3 8⅞	4 2⅛	4 7⅛	5 0⅛
127	1 8⅛	2 1¼	2 6¼	2 11⅜	3 4½	3 9¼	4 2½	4 7½	5 0⅝
128	1 8⅜	2 1⅜	2 6½	2 11⅝	3 4¾	3 9⅝	4 2⅞	4 8	5 1⅛
129	1 8½	2 1⅝	2 6¾	2 11⅞	3 5	3 10	4 3¼	4 8½	5 1½
130	1 8⅝	2 1⅞	2 7	3 0¼	3 5⅜	3 10⅜	4 3¾	4 9	5 2
131	1 8¾	2 2	2 7¼	3 0½	3 5⅝	3 10¾	4 4⅛	4 9⅜	5 2½
132	1 9	2 2¼	2 7½	3 0¾	3 6	3 11	4 4½	4 9¾	5 3
133	1 9⅛	2 2½	2 7¾	3 1	3 6¼	3 11½	4 4⅞	4 10¼	5 3½
134	1 9¼	2 2⅝	2 7⅞	3 1¼	3 6⅝	3 11⅞	4 5¼	4 10⅝	5 4
135	1 9½	2 2⅞	2 8¼	3 1½	3 6⅞	4 0⅛	4 5¾	4 11	5 4½
136	1 9⅝	2 3	2 8½	3 1⅞	3 7¼	4 0½	4 6⅛	4 11½	5 5
137	1 9¾	2 3¼	2 8¾	3 2⅛	3 7½	4 0⅞	4 6½	5 0	5 5⅜
138	1 9⅞	2 3½	2 9	3 2⅜	3 7⅞	4 1¼	4 6⅞	5 0⅜	5 5⅞
139	1 10⅛	2 3¾	2 9⅛	3 2¾	3 8¼	4 1½	4 7¼	5 0⅞	5 6¼
140	1 10¼	2 3⅞	2 9⅜	3 3	3 8½	4 1⅞	4 7¾	5 1¼	5 6¾
141	1 10½	2 4	2 9⅝	3 3¼	3 8⅞	4 2¼	4 8⅛	5 1¾	5 7¼
142	1 10⅝	2 4¼	2 9⅞	3 3½	3 9⅛	4 2⅝	4 8½	5 2⅛	5 7¾
143	1 10¾	2 4½	2 10⅛	3 3⅞	3 9½	4 3	4 8⅞	5 2½	5 8¼
144	1 10⅞	2 4⅝	2 10⅜	3 4⅛	3 9¾	4 3⅜	4 9¼	5 3	5 8¾
145	1 11	2 4⅞	2 10⅝	3 4⅜	3 10⅛	4 3¾	4 9⅝	5 3½	5 9¼
146	1 11¼	2 5	2 10¾	3 4⅝	3 10½	4 4	4 10	5 4	5 9¾
147	1 11⅜	2 5¼	2 11	3 4⅞	3 10¾	4 4½	4 10½	5 4⅜	5 10⅛
148	1 11⅝	2 5½	2 11¼	3 5¼	3 11⅛	4 4⅞	4 10⅞	5 4¾	5 10⅝
149	1 11¾	2 5⅝	2 11½	3 5½	3 11½	4 5⅜	4 11¼	5 5¼	5 11⅛
150	1 11⅞	2 5⅞	2 11¾	3 5¾	3 11¾	4 5½	4 11⅝	5 5⅝	5 11⅝

Number of Teeth.	Pitch of the Teeth in inches.								
	1⅝	1¾	1⅞	2 in.	2⅛	2¼	2½	2¾	3 in.
	Diameter of Pitch Circle in feet and inches.								
126	5 4¾	5 10⅛	6 2¾	6 8¼	7 1¼	7 6	8 4¼	9 2¼	10 0¼
127	5 5¼	5 10¾	6 3⅜	6 8⅞	7 2	7 6⅝	8 5	9 3⅛	10 1¼
128	5 5⅞	5 11¼	6 4	6 9½	7 2½	7 7¼	8 5⅞	9 4	10 2¼
129	5 6⅜	5 11⅞	6 4½	6 10⅛	7 3¼	7 8	8 6⅝	9 4⅞	10 3⅛
130	5 6⅞	6 0⅜	6 5⅛	6 10¾	7 4	7 8¾	8 7½	9 5¾	10 4⅛
131	5 7⅜	6 1	6 5¾	6 11⅜	7 4½	7 9½	8 8¼	9 6⅝	10 5
132	5 7⅞	6 1½	6 6⅜	7 0	7 5⅛	7 10⅛	8 9	9 7½	10 6
133	5 8⅜	6 2	6 7	7 0⅝	7 6	7 10⅞	8 9¾	9 8⅜	10 7
134	5 8⅞	6 2⅝	6 7½	7 1¼	7 6⅝	7 11½	8 10⅝	9 9¼	10 8
135	5 9½	6 3⅛	6 8⅛	7 2	7 7¼	8 0¼	8 11⅜	9 10⅛	10 8⅞
136	5 10	6 3¾	6 8¾	7 2½	7 8	8 1	9 0¼	9 11	10 9¾
137	5 10½	6 4¼	6 9¼	7 3¼	7 8⅝	8 1¾	9 1	10 0	10 10¾
138	5 11	6 4¾	6 10	7 3¾	7 9¼	8 2½	9 1¾	10 0⅞	10 11¾
139	5 11½	6 5½	6 10½	7 4½	7 10	8 3⅛	9 2⅝	10 1⅝	11 0⅝
140	6 0	6 6	6 11⅛	7 5⅛	7 10⅝	8 3⅞	9 3⅜	10 2½	11 1⅝
141	6 0½	6 6½	6 11¾	7 5¾	7 11⅜	8 4½	9 4¼	10 3⅜	11 2½
142	6 1	6 7	7 0¼	7 6¾	8 0	8 5¼	9 5	10 4¼	11 3½
143	6 1½	6 7⅝	7 0⅞	7 7	8 0¾	8 6	9 5¾	10 5⅛	11 4½
144	6 2	6 8¼	7 1½	7 7⅝	8 1⅜	8 6¾	9 6	10 6	11 5½
145	6 2½	6 8¾	7 2	7 8¼	8 2	8 7½	9 7⅜	10 6⅞	11 6½
146	6 3	6 9¼	7 2⅝	7 9	8 2¾	8 8⅛	9 8⅛	10 7¾	11 7⅜
147	6 3½	6 9⅞	7 3¼	7 9½	8 3⅜	8 3⅞	9 9	10 8⅝	11 8¼
148	6 4	6 10½	7 3⅞	7 10¼	8 4⅛	8 9½	9 9¾	10 9½	11 9¼
149	6 4½	6 11	7 4½	7 10¾	8 4⅞	8 10¼	9 10½	10 10⅜	11 10¼
150	6 5⅛	6 11½	7 5	7 11½	8 5½	8 11	9 11⅜	10 11¼	11 11¼

ON STEAM AND THE STEAM ENGINE.

Steam is pure fresh water in an aeriform state, through the absorption of caloric, or the matter of heat.

All waters impregnated with foreign substances are deleterious to the economic production of steam. Fresh water of average quality boils under atmospheric pressure at 212° Fahrenheit, and one cubic inch produces about one cubic foot of steam equal in pressure to that of the atmosphere, but only considered of any effective benefit as a motive agent in that of the condensing engine, in which a more or less vacuum is obtained through the medium of the condenser and air pump.

Steam is distinguished in practice by the terms, "low pressure" and "high pressure," in accordance with density, and because in a condensing engine, if a pure vacuum could be obtained, the effective atmospheric pressure, plus 15 of indicated pressure, would equal 30 lbs. per square inch of useful productive effect; hence the common appellation, "low-pressure steam." Again, the atmospheric pressure being equal to 15 lbs., in round numbers, per square inch, the steam in a non-condensing engine has that resistance to overcome; therefore 30 lbs. of indicated pressure in non-condensing engines are only equal to 15 of indicated pressure in those of the condensing principle; for which reason steam of that density and above is designated steam of high pressure, or high-pressure steam.

Steam is frequently separated by another vessel from its water of formation, and subjected to a greater degree of heat, whereby the watery particles of which it is composed are diminished in bulk but augmented in quantity and elastic force, through excess of caloric, and commonly termed superheated steam.

Steam to which heat is applied after being separated from its water of formation, is subject to the same laws of expansion as atmospheric air and gases generally, the increase in volume from unity being 1·375 for 180 degrees of elevated temperature; hence the rule—To the degrees of temperature before and after expansion, add the constant number 459, divide the greater sum by the lesser, multiply the quotient by the volume at the lower temperature, and the product is the expanded volume in equal terms of unity.

Ex. If the volume of steam produced from water at 212° Fahrenheit equal 1711 times the bulk of the water from which it is produced, what will be the expanded volume at 250·3°, supposing the pressure to be the same in both cases?

$$\frac{250{\cdot}3 + 459}{212 + 459} = \frac{709{\cdot}3}{671} \times 1711 = 1808{\cdot}66$$

To find the elastic force of steam at any given temperature:—

Rule.—To the indicated temperature of the steam in degrees of Fahrenheit add 100, multiply the sum by ·00564, and the sixth power of the product equal the force in inches of mercury, which being multiplied by ·491, equal lbs. per square inch elastic force.

Ex. Suppose steam at a temperature of 262° Fahrenheit.

$262° + 100 \times {\cdot}00564 = 2{\cdot}041686^6 = 74$ inches of mercury, and $74 \times {\cdot}491 = 36{\cdot}3$ lbs. elastic force.

Steam possesses the property of expansive force, and in the following ratio, viz.: If expanded to double its volume of formation, its retaining force equals one-half, if to three times its volume, one-third, if to four times its volume, one-fourth, &c., in an inverse ratio with the degree of expansion; hence the beneficial properties of high-pressure steam in preference to low pressure in the economical working of a steam engine, if cut off early in the stroke, and continued to the end by expansive force. Thus, let dense steam be stopped off from the cylinder of an engine at one-half the stroke, the mean elastic force of the steam throughout the whole stroke equal 1·7; that is, the dense steam equal 1,—and the same steam expanded, terminates at half the original density, but by its increase of volume and diminution of elastic force, seven-tenths of the original elastic force are economised by the property of its expansion; and similar values are obtained in similar ratios when stopped off at any other point of the stroke, as in the following table:—

Steam stopped off at	$\frac{1}{2}$	of the stroke, the uniform elastic force by density and expansion equal	1·7	of mean elastic force throughout the whole stroke in terms of initial density.
	$\frac{1}{3}$		2·1	
	$\frac{1}{4}$		2·4	
	$\frac{1}{5}$		2·6	
	$\frac{1}{6}$		2·8	
	$\frac{1}{7}$		3·0	
	$\frac{1}{8}$		3·2	

To determine where steam of any given density must be cut off, so as to retain a certain amount of elastic force at the end, or any other required point of the stroke.

Rule.—Multiply the length of the stroke in inches by the required elastic force of the steam at the given point or termination of the stroke, as it may be, and divide the product by the given force of the dense steam; the quotient is the distance from commencement of the stroke at which the dense steam must be cut off.

Ex. Suppose steam at 20 lbs. per square inch, length of stroke 24 inches, and at the termination of the stroke the steam to have an elastic force of 7 lbs. per square inch.

$\frac{7 \times 24}{20} = 8·4$ inches from the commencement of the stroke.

Salt or sea water does not boil at an equal temperature with that of fresh water, consequently it is an inferior medium of calorific reception for the production of steam, and as the water becomes evaporated, so is saturation approximated and a higher temperature required to produce steam of equal density to that from fresh water.

Sea water naturally holds in solution about $\frac{1}{33}$rd its weight of salt, which becomes more and more augmented by evaporation, each grade as approaching to saturation requiring a higher degree of temperature in attaining the boiling point; thus, sea water in its natural state boils at 213·2° Fahrenheit; at $\frac{2}{33}$rds of saturation the boiling point is 214·4°; at $\frac{3}{33}$rds it is 215·5°; and at $\frac{4}{33}$rds the boiling point is elevated to 216·7°: and which grade of saturation the water in any sea-going vessel's boilers ought never to be allowed to exceed.

Elastic force of steam, and corresponding temperature of the water with which it is in contact.

Pressure of steam per square inch, as indicated by steam pressure gauge, or safety valve. lbs. Avs.	Temperature in degrees of			Volume of steam compared with volume of water.	Cubic inches of water in a cubic foot of steam.
	Fahrenheit.	Reaumur.	Centigrade		
1	216·3	81·9	102·4	1573	1·099
2	219·6	83·3	104·2	1488	1·162
3	222·7	84.7	105·9	1411	1·226
4	225·6	86·0	107·6	1343	1·287
5	228·5	87·3	109·2	1281	1·350
6	231·2	88·5	110·7	1225	1·411
7	233·8	89·7	112·1	1174	1·474
8	236·3	90·8	113·5	1127	1·536
9	238·7	91·9	114·8	1084	1·597
10	241·0	93·0	116·1	1044	1·658
11	243·3	93·9	117·4	1007	1·719
12	245·5	94·9	118·6	973	1·779
13	247·6	95·8	119·8	941	1·840
14	249·6	96·7	120·9	911	1·910
15	251·6	97·6	122·0	883	1·959
16	253·6	98·5	123·1	857	2·021
17	255·5	99·3	124·2	833	2·079
18	257·3	100·1	125·2	810	2·138
19	259·1	100·9	126·2	788	2·198
20	260·9	101·7	127·2	767	2·258
21	262·6	102·5	128·1	748	2·316
22	264·3	103·2	129·1	729	2·376
23	265·9	104·0	129·9	712	2·433
24	267·5	104·7	130·8	695	2·493
25	269·1	105·4	131·7	679	2·552
26	270·6	106·0	132·6	664	2·610
27	272·1	106·7	133·4	649	2·670
28	273·6	107·4	134·2	635	2·725
29	275·0	108·0	135·0	622	2·787
30	276·4	108·6	135·8	610	2·842

	lbs. Avs.	Temperature in degrees of			Volume of steam compared with volume of water.	Cubic inches of water in a cubic foot of steam.
		Fahrenheit.	Reaumur.	Centigrade		
Pressure of steam per square inch, as indicated by steam pressure guage, or safety valve.	31	277·8	109·2	136·8	598	2·899
	32	279·2	109·9	137·3	586	2·958
	33	280·5	110·4	138·1	575	3·015
	34	281·9	111·1	138·8	564	3·074
	35	283·2	111·6	139·6	554	3·130
	36	284·4	112·2	140·2	544	3·188
	37	285·7	112·8	140·9	534	3·248
	38	286·9	113·3	141·6	525	3·304
	39	288·1	113·8	142·3	516	3·361
	40	289·3	114·4	142·9	508	3·415
	41	290·5	114·9	143·6	500	3·562
	42	291·7	115·4	144·3	492	3·469
	43	292 9	116·0	144·9	484	3·526
	44	294·2	116·5	145·7	477	3·585
	45	295·6	117·2	146·4	470	3·700
	46	296·9	117·7	147·2	463	3·756
	47	298·1	118·3	147·8	456	3·814
	48	299·2	118·8	148·4	449	3·865
	49	300·3	119·2	149·1	443	3·927
	50	301·3	119·7	149·6	437	3·981
	51	302·4	120·2	150·2	431	4·037
	52	303·4	120·6	150·8	425	4·094
	53	304·4	121·1	151·3	419	4·143
	54	305·4	121·5	151·9	414	4·204
	55	306·4	122·0	152·4	408	4·256
	56	307·4	122·4	153·0	403	4·309
	57	308·4	122·8	153·6	398	4·363
	58	309·3	123·2	154·1	393	4·419
	59	310·3	123·7	154·6	388	4·476
	60	311·2	124·1	155·1	383	4·535
	61	312·2	124·5	155·7	379	4·583
	62	313·1	124·9	156·2	374	4·645
	63	314·0	125·3	156·7	370	4·695

Pressure of steam per square inch, as indicated by steam pressure gauge, or safety valve. lbs. Avs.	Temperature in degrees of			Volume of steam compared with volume of water.	Cubic inches of water in a cubic foot of steam.
	Fahrenheit.	Reaumur.	Centigrade		
64	314·9	125·7	157·2	366	4·747
65	315·8	126·1	157·7	362	4·812
66	316·7	126·5	158·2	358	4·826
67	317·6	126·9	158·7	354	4·881
68	318·4	127·3	159·1	350	4·937
69	319·3	127·7	159·6	346	4·994
70	320·1	128·0	160·1	342	5·052
71	321·0	128·4	160·6	339	5·097
72	321·8	128·8	161·0	335	5·158
73	322·6	129·2	161·4	332	5·205
74	323·5	129·6	161·9	328	5·268
75	324·3	129·9	162·4	325	5·317
76	325·1	130·3	162·8	322	5·366
77	325·9	130·6	163·3	319	5·416
78	326·7	131·0	163·7	316	5·468
79	327·5	131·3	164·2	313	5·521
80	328·2	131·6	164·8	310	5·574

NOTE.—In the application of any of the above indicated pressures of steam to a condensing engine, 15 lbs., or one atmosphere, must be added, because the effective pressure in a condensing engine is the indicated pressure plus the atmospheric pressure, minus the resisting vapour remaining in the condenser, as shown by any indicator diagram taken from the cylinder, by which to test the merits or demerits of the engine in regard to useful effect.

Thus, suppose an indicated pressure of 18 lbs. per square inch is applied to a condensing engine, 18 + 15 = 33 lbs. as initial density, but the diagram taken shows existing vapour in the condenser, or other defects equal to 5½ lbs.; consequently, 33 – 5½ = 27½ lbs. per square inch of effective force upon the piston's area.

The steam engine is rendered an available source of motive power through the following innate properties of steam, viz.:—elastic force, expansive force, and ready submission to the destruction of its aeriform state through the abstraction of its heat by cold water, thus constituting the principles of the condensing engine.

In engines on the non-condensing principle condensation of the steam is evaded by excess of density, and after having performed its duty in the cylinder, it is allowed to escape into the atmosphere; hence, the atmospheric pressure on the boiler is a counterpoise to the effluent steam from the cylinder, minus its resistance by velocity against the pressure of the atmosphere.

Steam, as regards its various theoretical vicissitudes of beneficial effect in the steam engine, has long been investigated and experimented upon by eminent engineers, and the results of their researches and experiments have been given as data by which to construct upon, both relative to economy and design of modification, suitable to the numerous useful purposes to which the steam engine is applied.

In the constructing and working of stationary engines, it is necessary to be guided by some restricted velocity for the piston in a given time (*say feet per minute*), whereby to effect a maximum of power from a given pressure of steam necessary to the required performance of machinery, &c., at a steady uniform rate of motion; but engines for marine purposes, or for locomotive purposes, have no restricted velocities to contend with, otherwise than economising of fuel and unavoidable want of steam occasionally.

Several empirical rules have been, and still are, in use, whereby to determine the most advantageous velocities for the pistons of steam engines, through which to obtain a maximum of useful effect; but, having found them so contradictory, I have abandoned the idea of any rule in that respect, and substituted the following table, being from the practice of eminent engineers, and combined with my own practical observations, as strictly attended to.

Table of Velocities for the Pistons of Stationary Engines, with given lengths of stroke.

Condensing Engines.			Non-Condensing Engines.		
Length in feet and inches.	Number per minute.	Velocity in feet per minute.	Length in feet and inches.	Number per minute.	Velocity in feet per minute.
2 0	42	168	0 9	100	150
2 3	38	171	1 0	80	160
2 6	35	175	1 3	70	175
2 9	32	176	1 6	62	186
3 0	30	180	1 9	55	192½
3 3	28½	185¼	2 0	50	200
3 6	27	189	2 3	46	207
3 9	26	195	2 6	42½	212½
4 0	25	200	2 9	39½	217¼
4 6	23	207	3 0	37	222
5 0	21½	215	3 3	35	228½
5 6	20	220	3 6	33	231
6 0	19	228	3 9	31	232½
6 6	18¼	237¼	4 0	29½	236
7 0	17½	245	4 6	27	243
8 0	16	256	5 0	24¾	247½

The useful effect of steam engines, independent of locomotives, is estimated in terms of horses' power, one horse's power being an equivalent to 33,000 lbs. Avoirdupois, raised through one foot per minute; but the density of the steam taken into calculation causes a distinction of terms of expressed effect, the one being taken at a constant uniform pressure of 7 lbs. per square inch, which constitutes nominal horses' power; the other is the mean effective pressure of steam taken by an Indicator, and called actual horses' power. The following are the general relative rules:—

Rule 1.—Divide the product of 33000 multiplied by the required number of horses' power, by the product of the velocity in feet per minute, multiplied by 7 lbs. per square inch, and the quotient is the piston's area in square inches.

Rule 2.—Multiply the piston's area in square inches by its velocity in feet per minute and by 7 lbs.; divide the product by 33000, and the quotient is the expressed effect in nominal horses' power.

Ex. 1. Required the diameter of cylinder for a condensing engine of 24 nominal horses' power, the length of stroke being 4½ feet, or 207 feet velocity per minute.

$$\frac{33000 \times 24}{207 \times 7} = \frac{792000}{1449} = 546{\cdot}6 \text{ inches area, or } 26\tfrac{3}{8} \text{ inches diameter.}$$

Ex. 2. What is the power of a condensing engine nominally, whose cylinder is 26⅜ inches diameter, and velocity of piston 207 feet per minute?

$26{\cdot}375^2 \times {\cdot}7854 = 546{\cdot}6$ square inches area.

$$\text{Then } \frac{546{\cdot}6 \times 7 \times 207}{33000} = \frac{792023{\cdot}4}{33000} = 24 \text{ horses' power.}$$

High-pressure, or non-condensing, engines can only properly be estimated in actual horses' power, because it is from the steam's density and velocity that the total amount of useful effect is produced; hence, restricted velocity for calculation of effect is required, which the preceding table of velocities will supply (see page 65), the length of stroke being about three times the cylinder's diameter.

Ex. 1. What must be the diameter of cylinder for a high-pressure engine of 16 horses' power, with a stroke of 3 feet, or 222 feet velocity per minute; the dense steam equal 40 lbs. per square inch, and cut off at ½ stroke?

Mean elastic force of steam (as per table, page 70), = 33·86 lbs. per square inch.

$$\text{Then, } \frac{33000 \times 16}{33{\cdot}86 \times 222} = \frac{528000}{7516{\cdot}92} = 70{\cdot}25 \text{ square inches area, or } 9\tfrac{5}{8} \text{ inches diameter.}$$

Ex. 2. The diameter of the cylinder of a non-condensing engine is 14 inches, length of stroke 3½ feet, dense steam 40 lbs. per square inch, and cut off at ⅜ths of the stroke,—required the actual horses' power.

Area = 154 square inches;
Mean elastic force of steam = 36·15 lbs.;
Velocity of piston in feet per minute = 231.

$$\text{Then, } \frac{154 \times 36{\cdot}15 \times 231}{33000} = \frac{1286000}{33000} = 38{\cdot}9 \text{ horses' power.}$$

Note.—The diameters of circles, consequently the diameters of cylinders, are obtained either by dividing the area by ·7854 and extracting the square root of the quotient, or by multiplying the square root of the area by 1·12837; otherwise refer immediately to the tables of areas and circumferences in this work; but if the tables are not sufficiently extended, divide the area by 4, and twice the diameter opposite the quotient in areas equal the diameter required. Thus, suppose the area $\frac{546{\cdot}6}{4} = 136{\cdot}66$, the diameter of which equal $13\frac{3}{16}$, and twice $13\frac{3}{16} = 26\frac{3}{8}$, the diameter as required.

Approximate Rules relating to non-condensing Steam Engines.

1. To find the power of an engine, the diameter of cylinder and pressure or force of dense steam being given.

Rule.—Multiply the square of the cylinder's diameter in inches by the force of the steam in lbs. per square inch, and by ·003, the product is the number of horses' power nominally that the engine is estimated equal to.

Ex. Required the power of an engine with a cylinder of 9 inches diameter, and steam at 35 lbs. per square inch.

$$9^2 = 81 \times 35 = 2835 \times {\cdot}003 = 8{\cdot}5 \text{ horses' power.}$$

2. To determine the diameter of cylinder for an engine of a required power nominally, and with a given pressure of steam:—

Rule.—Multiply the required number of horses' power by 334, and divide the product by the force of the steam in lbs. per square inch; the square root of the quotient is the cylinder's diameter in inches.

Ex. What must be the diameter of the cylinder for a 6-horse engine, with steam at 30 lbs. per square inch?

$$334 \times 6 = \frac{2004}{30} = \sqrt{66{\cdot}8} = 8{\cdot}173, \text{ or } 8\tfrac{3}{16} \text{ ins. in diameter.}$$

Table of the diameters of cylinders for condensing engines of nominal horses' power, the strokes of proportionate lengths, and the dense steam 7 lbs. per square inch above atmospheric pressure.

Stationary Engines.					Marine Engines.		
Nominal horses' power.	Diameter of cylinder in inches.	Length of stroke in feet.	Number of strokes per minute.	Velocity in feet per minute.	Nominal horses' power.	Diameter of cylinder in inches.	Length of stroke in feet.
10	18	3¼	28½	185¼	16	24⅛	2½
12	19½	3½	27	189	20	26⅛	”
14	21	”	”	”	25	28⅛	3
15	21½	3¾	26	195	30	31⅛	”
16	22	4	25	200	40	36½	3¼
18	23	4¼	24	204	50	39½	3½
20	24⅛	4½	23	207	60	43	4
24	26⅛	4¾	22	209	70	46	4¼
25	26¾	5	21½	215	80	48	4½
28	27⅛	5½	20	220	90	50	4¾
30	28½	”	”	”	100	52½	5
35	30⅛	5¾	19½	224¼	110	55	”
40	32⅛	6	19	228	120	57	5½
45	34¼	”	”	”	130	59	”
50	36	6¼	18½	231¼	150	62⅛	6
60	39	6½	18	234	200	71⅛	6½

NOTE.—The diameter of air pump for any stationary engine equal ·67; and the diameter for the same in a marine engine equal ·58 of the cylinder's diameter in inches, at half the stroke of the engine.

Table of the diameters of cylinders for non-condensing engines of actual horses' power, the strokes of proportionate lengths, the dense steam 30 lbs. per square inch, and cut off at ¾ths of the stroke.

Horses' power.	Diameter of cylinder in inches.	Length of stroke in inches.	Number per minute.	Velocity in feet per minute.
1	3⅛	9	100	150
2	4¼	12	80	160
3	5	15	70	175
4	5¾	—	—	—
5	6¼	18	62	186
6	6¾	21	55	192½
7	7⅛	—	—	—
8	7⅝	24	50	200
9	8⅛	—	—	—
10	8⅜	27	46	207
12	9⅛	—	—	—
14	9¾	30	42½	212½
16	10⅜	—	—	—
18	11	33	39½	217¼
20	11½	—	—	—
25	12¾	36	37	222

For the necessary production of steam 25 cubic inches of water is required per minute for each horse power, not including waste and other contingencies; hence not less than 35 cubic inches, or about one-eighth of a gallon, can be estimated as a reliable quantity per horse power.

NOTE.—The dense steam at 30 lbs. per square inch, and continued to ¾ths of the stroke in a non-condensing engine, is considered a fair average effective power per horse, in a commercial point of view.

Table of the mean elastic force of steam in pounds per square inch in a steam engine, at various grades of expansion.

	Initial density of the steam in lbs. per square inch.	Dense steam cut off after the piston has passed through the following parts of the stroke, viz. :—						
		⅕ or ·2	¼ or ·25	⅖ or ·4	½ or ·5	⅗ or ·6	¾ or ·75	⅘ or ·8
Atmospheric pressure not included	9	4·69	5·37	6·89	7·62	8·13	8·67	8·80
	10	5·22	5·97	7·67	8·46	9·03	9·64	9·78
	11	5·74	6·56	8·43	9·31	9·94	10·60	10·76
	12	6·26	7·16	9·19	10 16	10·84	11·57	11·74
	13	6·78	7·75	9·96	11·01	11·75	12·53	12·72
	14	7·31	8·53	10·73	11·85	12·65	13·49	13·97
	15	7·83	8·95	11·49	12·69	13.55	14·46	14·68
	16	8·35	9·54	12·26	13·54	14·46	15·42	15·66
	17	8·87	10·14	13·03	14·39	15·36	16·38	16·63
	18	9·39	10·74	13·79	15·24	16·27	17·35	17·61
	19	9·92	11·33	14·56	16·81	17·17	18·31	18·59
	20	10·44	11·93	15·33	16·93	18·07	19·28	19·57
	25	13·04	14·91	19·16	21·16	22·59	24·09	24·46
	30	15·65	17·89	22·99	25·39	27·11	28·91	29·35
	35	18·26	20·88	26·83	29·63	31·63	33·73	34·24
	40	20·87	23·86	30·66	33·86	36·15	38·55	39·04
	45	23·48	26·84	34·88	38·09	40·66	43·37	44·03
	50	26·09	29·82	38·32	42·33	45·18	48·19	48·92

Ex. If dense steam be admitted to the cylinder of an engine at 35 lbs. per square inch, and cut off when the piston has moved through ⅗ths of the stroke, the mean elastic pressure during the whole stroke is 31·63 lbs. per square inch, as obtained by initial density and expansive force.

On Steam Boilers.

In the formation or construction of boilers for steam engines, safety and economy are the principal restrictions: capacity for water and steam, superficial heating surface, and sufficient area of fire grate unconfined for ignition of the gases, are laid down as acknowledged rules, viz., 25 to 27 cubic feet capacity, 9 to 12 square feet heating surface, and not less than ¾ths of a square foot of fire grate surface to each nominal horse power; but, relative to fire grate surface, it is only where coal is used as fuel that the given dimensions apply. Where wood is the fuel employed, a much greater fire surface is required, particularly in length, so as to receive the billets cut at convenient lengths; and in tropical climates generally, it is highly recommended to form, if possible, a stream of running water in the direction of the flame, fore and aft the boiler, covered in its length everywhere, but immediately under the fire grate. I found the plan very beneficial in India, South America, and in some parts of Australia, where megass or crushed sugar cane, and wood are the only fuels that can at any reasonable rate be obtained. The stream suits the two-fold purpose of carrying away the falling ashes from the fire, and also assists in maintaining a colder current of atmospheric air to the fire for the support of combustion.

Thin films of water as water spaces in boilers are very objectionable, and ought to be carefully avoided, where possible, in the construction, particularly over fierce fire or flame in a horizontal position; and even vertical water spaces ought to be wider at top than bottom, so as to allow more free egress for the steam in its formation. Again, in flat surfaces stays are unavoidable; but in the wear of boilers anxious examination, whenever an opportunity occurs, ought not to be neglected, as frequently an action takes place around the ends or nuts of some of the stays inside the boiler, as if the plate had been put upon a face plate in a lathe and hollowed out with a round pointed tool.

Table of Dimensions for boilers of a cylindrical form, the engines of nominal horses' power.

Number of horses' power.	Length of boiler in feet.	Length of fire bars in feet & ins.	Diam. of boiler in feet.	Width of furnace.	Number of and diam. of flues.	
				ft. in.		
1	6	1 7	2¼	1 4	no flue.	—
2	7½	2 0	2½	1 6		—
3	9	2 4	2¾	1 8		—
4	10	2 9	3	1 9		—
5	11	2 11	3½	2 0		—
						ft. in.
6	12	3 2	3¾	2 3	one flue.	1 6
8	14	3 8	4	2 4		1 8
10	15½	4 0	4½	2 8		1 11
12	16	4 2	5	2 11		2 0
14	17½	4 7	5¼	3 0		2 3
15	18	4 9	5⅜	3 2		2 4
16	18½	4 10	5½	3 3	two flues	1 7
18	19	5 0	5¾	3 4		1 8
20	20½	5 4	6	3 6		1 9
25	22¼	5 9	6¾	3 11		2 0

NOTE.—For greater powers of engines two boilers are preferable to one of extended dimensions.

To find the indicated pressure, force, or density of steam by a properly adjusted safety valve.

RULE—Multiply the square of the opening in the boiler or narrowest diameter of the valve seat by ·7854, and the product is the area in terms of the dimensions given.

Ex. 1. Let the diameter of opening or seat of valve equal 6⅜ inches, required the area.

$6{\cdot}375^2 = 40{\cdot}64 \times {\cdot}7854 = 31{\cdot}9$ &c. square inches.

Suppose an indicated pressure of 12 lbs. per square inch is required, and the weight attached to the valve, the weight of valve and attachments 16½ lbs., what weight will be required?

$$31{\cdot}9 \times 12 = 382{\cdot}8 - 16{\cdot}5 = 366{\cdot}3 \text{ lbs.}$$

If the pressure on a safety valve is to be effected by a lever and weight, or by a lever and spring balance, fix the lever properly into its situation; then, with a spring balance attached immediately at that point of the lever where it rests upon the valve, raise the spring balance by hand until the lever is level, then the index of the spring balance will show the amount of action or downward tendency the lever has, by gravity and leverage, to press down the valve. Multiply the total pressure of steam required upon the valve by the distance between the centre of pin on which the lever moves, and centre of valve; subtract from the product the action of the lever, plus the weight of the valve, divide the remainder by the distance between centre of pin and weight or spring balance attached to the lever, the quotient is the weight required or indicated pressure by spring balance, when steam is just at point of blowing off.

Take the preceding example as the area of valve and pressure of steam required, distance from centre of pin to centre of valve 6½ inches, distance from centre of pin to weight or spring balance 32½ inches, action of lever 14 lbs, weight of valve 7¼ lbs, and required pressure 12 lbs. per square inch.

Area of valve = 31·9 square inches × 12 lbs. = 382·8 lbs. total pressure required.

Action of lever and weight of valve = 14 + 7·25 = 21·25 lbs.; then,

$$382{\cdot}8 \times 6{\cdot}5 = 2488{\cdot}2 - 21{\cdot}25 = \frac{2466{\cdot}95}{32{\cdot}5} = 76 \text{ lbs. to be}$$

suspended by the lever at that point, or indicated weight by spring balance.

Again: suppose all circumstances as above, what will be the pressure on each square inch of the safety valve?

$$32{\cdot}5 \times 76 = 2470 + 21{\cdot}25 = 2491{\cdot}25\text{; and}$$

$$31{\cdot}9 \times 6{\cdot}5 = 207{\cdot}35\text{; hence}$$

$$\frac{2491{\cdot}25}{207{\cdot}35} = 12 \text{ lbs. per square inch.}$$

Ex. 2. Suppose the diameter of a safety valve equal 4⅜ inches, the distance between centre of pin and centre of valve 5 inches, distance between centre of pin and point on the lever at which the weight is suspended equal 30 inches, weight of valve and action of lever 9 lbs., weight or indicated pressure by spring balance 76 lbs., required the pressure in lbs. per square inch on the valve.

$$4{\cdot}375^2 \times {\cdot}7854 = 15 \text{ inches area,}$$

$$\text{and } 76 \times 30 + 9 = 2239\text{, also } 15 \times 5 = 75\text{;}$$

$$\text{hence } \frac{2289}{75} = 30{\cdot}52 \text{ lbs. per square inch.}$$

Again, suppose the pressure is to be reduced to 25 lbs. per square inch, under the same circumstances; at what distance on the lever from the centre of pin must the weight or spring balance be placed?

$$15 \times 25 - 9 = 366 \times 5 = \frac{1830}{76} = 24 \text{ inches.}$$

Sometimes where it is inconvenient, for the want of a spring balance, to ascertain the action of the lever on a safety valve, the lever is extended in length beyond its pin or fulcrum on which it moves, and a small ball of any metal attached, as a counterpoise to the lever.

As a rule for the proportioning of safety valves with levers, the distance between fulcrum and centre of valve equal the diameter of the valve, and the distance between weight or spring balance as many times the valve's diameter as there are square inches in its area.

ON LOCOMOTIVE ENGINES.

Table of co-efficients for facilitating the computation of effect by Locomotive Engines.

Length of stroke in inches	Diameter of Driving Wheels in Feet.						
	4	4½	5	5½	6	6½	7
	Co-efficients.						
20	·2652	·2393	·2122	·1929	·1768	·1632	·1516
19	·2519	·2273	·2016	·1832	·1679	·1550	·1440
18	·2386	·2153	·1910	·1736	·1591	·1468	·1364
17	·2254	·2034	·1803	·1640	·1503	·1387	·1288
16	·2121	·1914	·1697	·1543	·1415	·1305	·1213
15	·1989	·1795	·1591	·1447	·1326	·1224	·1137
14	·1856	·1675	·1485	·1350	·1237	·1141	·1061
13	·1724	·1555	·1379	·1254	·1149	·1061	·0985
12	·1591	·1436	·1273	·1157	·1061	·0979	·0909

1. To determine the amount of tractive power a locomotive engine is capable of exerting on a level line of railway with a given force or pressure of steam, the following being given, viz.:—

Diameter of cylinder.
Length of stroke.
Diameter of driving wheels.
Indicated force or density of steam.
Pounds per ton of tractive power.

Rule.—Multiply the sum of the areas of the pistons in inches by the given pressure of steam in lbs., and by the co-efficient in the table coinciding with the length of stroke and diameters of driving wheels; the product is the total amount of tractive power in lbs.—Divide the product by the tractive power per ton in lbs., and the quotient is the gross load the engine is equal to in tons on a level railway.

Ex. Suppose an engine with cylinders of 13 inches diameter, stroke 18 inches in length, driving wheels 5½ feet in diameter, and steam at 40 lbs. per square inch, required the gross load in tons the engine's power is equal to.

$$\begin{array}{rl}
13^2 \times \cdot 7854 = 132\cdot 7 & \text{inches in area.} \\
\times \quad 2 & \text{in number.} \\
\hline
265\cdot 4 & \\
\times \quad 40 & \text{lbs. per square inch.} \\
\hline
10616\llcorner\underline{0} & \\
\times \quad \cdot 1736 & \text{co-efficient.} \\
\hline
1842\cdot 9376 & \text{or 1843 lbs. tractive power.}
\end{array}$$

Then 1843 ÷ 9·5 = 194 tons gross load; and suppose the engine and tender equal 18 tons,—194−18 = 176 tons weight of train.

2. To ascertain what pressure of steam is necessary for a locomotive engine of given weight and dimensions, with a known weight of train attached.

Rule.—Multiply the sum of the areas of the cylinders by the proper co-efficient, as before described, for a divisor; again multiply the gross load of the train in tons by the tractive power in lbs. per ton; divide the product by the divisor, and the quotient is the indicated pressure of steam required in lbs. per square inch.

Ex. An engine and tender of 18 tons in weight, and train 176, or gross weight 194 tons, what force of steam per square inch will be required with the above engine to transport that load upon a level line?

$$\begin{array}{rl}
265\cdot 4 & \text{sum of the two areas.} \\
\times \quad \cdot 1736 & \text{co-efficient.} \\
\hline
15924 & \\
7962 & \\
18578 & \\
2654 & \\
\hline
46\cdot\llcorner\underline{07344} &
\end{array}
\qquad
\begin{array}{rl}
194 & \text{tons gross load.} \\
\times \quad 9\cdot 5 & \text{lbs. tractive power per ton.} \\
\hline
970 & \\
1746 & \\
\hline
1843\cdot 0 &
\end{array}$$

Hence 1843 ÷ 46 = 40 lbs. per square inch.

In ascending any inclined plane with an engine, the weight or resistance to traction is augmented by gravity as the rise or incline of the plane is to the height; hence if 1 ton, or 2240 lbs., be the unit of weight, 9½ lbs. the unit of traction per ton upon a level line, and 1 in 350 the inclination of the plane, then 2240 ÷ 350 = 6·4, and 9·5 + 6·4 = 15·9 lbs. or the force of traction for the same weight upon the incline.

Again, if the train be descending, the force of traction is diminished in an equal ratio, and the train accelerated by gravity; thus, 9·5 − 6·4 = 3·1 lbs. required for traction on the descending plane.

The resistance to any flat surface 1 foot square passing through a still atmosphere at about 1 mile per hour equal ·005 lbs. Avoir.; and the resistance increases as the square of the velocity. Hence, if a train expose an opposing frontage of 20 square feet at a velocity of 5 miles per hour, $5^2 \times 20 \times \cdot005 = 2$ lbs. resistance; but if the velocity be increased to 25 miles per hour, the opposing force of resistance on the same frontage equals $25^2 \times 20 \times \cdot005 = 62\cdot5$ lbs.

To find the time and distance that one railway train will overtake another, their rate of speed being known:—

RULE.—As the difference of the speed of the two bodies in motion is to the distance gone by one, so is the motion of the quicker body to the distance, or term required.

Ex. Suppose a train to be started at a given time, and to continue at the rate of 27 miles per hour; in 35 minutes after, a dispatch train is sent to overtake the first, at a continued speed of 33 miles per hour; how far will the first have gone when the second overtakes it?

33 − 27 = 6, and 27 ÷ 60 = ·42 miles per minute, the speed of first train;

Then ·42 × 35 = 14·7, and 6 : 14·7 : : 35 : 85·75 miles distant when overtaken;

And 6 : ·42 : : 35 : 2·45 hours, or 2 hours 27 minutes from the time of starting of the second train.

Table of Railway Gradients and resistance to trains per ton by inclination.

Vertical Rise		Ratio of Inclination.	Gravity due to incline per ton, in lbs.	Vertical Rise		Ratio of Inclination.	Gravity due to incline per ton, in lbs.
Per mile in feet.	Per chain in inches.			Per mile in feet.	Per chain in inches.		
		one in				one in	
5	·75	1056	2·12	28	4·20	188·6	11·89
6	·90	880	2·54	29	4·35	182·1	12·30
7	1·05	754·2	2·97	30	4·50	176	12·72
8	1·20	660	3·39	31	4·65	170·3	13·15
9	1·35	586·6	3·82	32	4·80	165	13·57
10	1·50	528	4·24	33	4·95	160	14·00
11	1·65	480	4·66	34	5·10	155·3	14·42
12	1·80	440	5·09	35	5·25	150·8	14·85
13	1·95	406·1	5·51	36	5·40	146·6	15·28
14	2·10	377·1	6·00	37	5·55	142·7	15·69
15	2·25	352	6·36	38	5·70	138·9	16·12
16	2·40	330	6·79	39	5·85	135·4	16·54
17	2·55	310·6	7·21	40	6·00	132	17·00
18	2·70	293·3	7·64	41	6·15	128·1	17·39
19	2·85	277·9	8·06	42	6·30	125·7	17·82
20	3.00	264	8·48	43	6·45	122·8	18·24
21	3·15	251·4	8·91	44	6·60	120	18·66
22	3·30	240	9·33	45	6·75	117·3	19·09
23	3·45	229·5	9·70	46	6·90	114·8	19·51
24	3·60	220	10·18	47	7·05	112·3	19·94
25	3·75	211·2	10·60	48	7·20	110	20·36
26	3·90	203·1	11·03	49	7·35	107·7	20·79
27	4·05	195·5	11·46	50	7·50	105·6	21·21

Useful notes connected with steam engines generally.

The proper length for the connecting rod of a beam engine, is the perpendicular distance between centre of beam axis and centre of fly wheel shaft.

The proper length for the side rods of a lever engine, is the perpendicular distance between the centre of lever and centre of piston cross-head at half stroke.

The proper length for connecting rods of direct action engines is, the distance between the centre of crank axle and centre of piston cross-head at half stroke.

The proper length for an eccentric rod is, the distance between centre of fly wheel shaft, or centre of revolution, and centre of stud in traverse shaft, when the valve is at half stroke.

To determine the proper velocity for the governor or regulator of a steam engine, or other motive power, the length of pendulums being given:—

RULE.—Divide 375 by twice the square root of the pendulum's length, and the quotient is the number of revolutions per minute.

Ex. What number of revolutions ought a governor to make per minute, whose pendulums are 24 inches in length?

$\sqrt{24} = 4{\cdot}899 \times 2 = 9{\cdot}798$, and $375 \div 9{\cdot}798 = 38{\cdot}27$ revolutions per minute.

To find the proper length of pendulums for a governor, when the number of revolutions per minute are given:—

RULE.—Divide 375 by twice the number of revolutions per minute, and the square of the quotient is the length of pendulums required.

Ex. When the given velocity for a governor is 38·27 revolutions per minute, what must be the length of pendulums?

$38{\cdot}27 \times 2 = 76{\cdot}54$, and $375 \div 76{\cdot}54 = 4{\cdot}9^2 = 24$ inches in length.

The governor of an engine is required to make 52 revolutions per minute during the same time the engine makes

66; on the fly-wheel shaft is fixed a 12 inch pulley, and on the bottom end of governor spindle a bevel wheel containing 36 teeth; required the diameter of intermediate pulley, and also the number of teeth in intermediate wheel by which to effect the proper velocity.

$66 \times 52 = \sqrt{3432} = 58{\cdot}58$ ratio of velocities;

Then $66 \times 12 = 792 \div 58{\cdot}58 = 13{\cdot}53$ inches, diameter of intermediate pulley;

And $52 \times 36 = 18720 \div 58{\cdot}58 = 32$ teeth in the intermediate wheel.

The first driving wheel from an engine or other motive power is 5 feet 6 inches in diameter at the pitch line, and contains 83 teeth; the engine makes 25 revolutions per minute, and the first line of shafting is to make 36 in the same time; what distance apart from centre to centre must the shafts be placed, and what must be the diameter of the other wheel at the pitch circle?

$5\frac{1}{2}$ feet $= 66$ inches $\div 2 = 33$;

Then $33 \times 25 = 825 \div 36 = 22{\cdot}9 \times 2 = 45{\cdot}8$ inches, diameter of second or driven wheel;

And $33 + 22{\cdot}9 = 55{\cdot}9$ inches distance of shafts from centre to centre.

Suppose a wheel or pulley of any given diameter or number of teeth, and at any given velocity—say, in this example, 45 revolutions per minute—what must be the diameter of another to be driven by it, and to make 18 revolutions in the same time?

$118 \div 45 = 2{\cdot}62$ ratio of velocities.

Let the first wheel or pulley equal 36 inches diameter; then $36 \div 2{\cdot}62 = 13{\cdot}74$, or $13\frac{3}{4}$ inches of smaller wheel or pulley; and if it be a toothed wheel, it must contain 14 teeth, being the nearest number.

Observe that intermediate wheels, of whatever number of teeth, whereby to communicate motion to another, at any distance apart, cause no variation in velocity, otherwise than would take place were the first and last in immediate contact

When a toothed wheel is caused to produce circular motion by the constant revolutions of a single-threaded screw, the number of revolutions of the screw to one of the wheel equal the number of teeth in the wheel, and as the number of threads in the screw is increased, so is the velocity of the wheel.

Promiscuous gleanings of rules, examples, and observations, for practical application of capacity, solidity, and density.

(See Table of Approximations, p. 21, relative to the following examples).

1. A rectangular cistern is in length 8½ feet, in width 5¼ feet, and in depth 4 feet; what is its capacity in cubic feet and also in imperial gallons?

$$8{\cdot}5 \times 5{\cdot}25 \times 4 = 178{\cdot}5 \text{ cubic feet, and}$$
$$178{\cdot}5 \times 6{\cdot}232 = 1112{\cdot}412 \text{ gallons.}$$

2. A rectangular cistern 7¼ feet in length, 4½ feet in width, the depth is required, so that it may be capable of containing 520 gallons.

$7{\cdot}25 \times 4{\cdot}5 \times 6{\cdot}232 = 203{\cdot}318$, and $\frac{520}{203{\cdot}318} = 2{\cdot}557$ feet in depth.

3. In a circular sinking in the earth of 4 feet 9 inches diameter, and 35 feet in depth, how many cubic yards excavated in its formation?

$$4{\cdot}75^2 \times 35 \times {\cdot}02909 = 22{\cdot}973 \text{ cubic yards.}$$

Suppose water to spring up in the above sinking until it attained a height of 16½ feet, how many gallons are therein contained, and how many gallons at each inch in depth?

$4{\cdot}75^2 \times 16{\cdot}5 \times 4{\cdot}896 = 1822{\cdot}162$ gallons the whole quantity, and 4·75 feet = 57 inches diameter.

Then $57^2 \times {\cdot}002832 = 9{\cdot}25$ gallons at each inch in depth.

4. A cylindrical cistern of sufficient capacity is to be formed so as to be capable of containing 12500 gallons, the depth to be 10 feet, required the diameter.

$4{\cdot}895 \times 10 = 48{\cdot}95$ and $\frac{12500}{48{\cdot}95} = \sqrt{255{\cdot}3} = 15{\cdot}96$ feet diameter

5. What diameter must I make a cylinder to contain 5 imperial gallons, the height or depth being intended 20 inches?

$$\frac{353 \times 5}{20} = \sqrt{88\cdot25} = 9\cdot4 \text{ inches diameter.}$$

6. What must be the diameter of a leaden ball to weigh 72 lbs. Avoirdupois?

$$\cdot5236 \times \cdot415 = \cdot217 \text{ and } \frac{72}{\cdot217} = 6\cdot91 \text{ inches diameter.}$$

NOTE.—The cube of the diameter of any sphere or ball multiplied by ·5236 equal its solidity, and ·415 equal the weight of a cubic inch of lead in lbs. Avoirdupois.

7. The length of a cast iron round solid shaft is 9½ feet and its diameter 6 inches, what is its estimated weight?

When the length is feet and the diameter inches, the multiplier is 2·48.

Then $6^2 \times 2\cdot48 \times 9\cdot5 = 848\cdot16$ lbs. Avoirdupois.

·009 is the approximate for cwts. (see table page 21),

$848\cdot16 \times \cdot009 = 7\cdot633$ cwts.

Let the same be of wrought iron, required the weight?

The multiplier for wrought iron is 2·6.

Then $6^2 \times 2\cdot65 \times 9\cdot5 = 906\cdot3$ lbs. Avoirdupois, and $906\cdot3 \times \cdot009 = 8\cdot1567$ cwts.

8. The internal diameter of a fly wheel rim of cast iron is 8 feet 4 inches, or 100 inches, the breadth of rim is 5 inches, and thickness 4, what is its weight in cwts.?

$$100 + 5 = 105 \times 5 \times 4 \times \cdot0074 = 15\cdot54 \text{ cwts.}$$

9. What ought the weight to be for the rim of a fly wheel proper for a steam engine of 20 horses' power, the wheel 16 feet external diameter, and velocity 21 revolutions per minute?

1368 (constant number) × 20 = 27360, and

$21 \times 16 = 336$, hence $\frac{27360}{336} = 81\cdot4$ cwts.

Properties of the Circle.

10. It is the most capacious geometrical figure known, bounded by equal perimeter or outline.

The diameter of a circle equal in area to 1 square unit is 1·1284, the circumference of which equal 3·545 in terms of the diameter.

A square of equal area is bounded by 4. And a rectangle of equal area, but its length four times its width, equal 5 in boundary line, inclosing only the same amount of areal space.

Circles are in proportion as the squares of their diameters. Any circle twice the diameter of another, contains four times the area of the other; hence, if the area of any circle is required to be divided into a given number of equal parts, or areas of the whole, square the circle's diameter, divide into the number of parts required, and the square root of each is the diameter of each, or as many as may be required in one area can be added into one sum, and the square root of that area equal the diameter.

The areal unit of square measure being 1, the areal unit of a circle equal ·7854, or half the circumference multiplied by half the diameter; hence, the area of any circle is equal to the square of its diameter multiplied by ·7854.

11. The diameter of a circle equal the sum of the squares of the chord of its segment and versed sine, divided by the versed sine; thus, suppose a segment whose chord is 18 and versed sine 6.

$18^2 + 6^2 = 360 \div 6 = 60$ the diameter of the circle, of which it is a part.

When the length of chord and diameter of circle is given, to find the versed sine or height of the segment:—

Rule.—To the radius of circle add half the length of chord, multiply the sum by their difference, and the square root of the product subtracted from the radius equal the versed sine.

Suppose the chord of the segment is in a circle of 60 feet diameter, required the versed sine.

$$\overline{30 + 18} = 48, \text{ and } 30 - 18 = 12, \text{ then}$$

$$48 \times 12 = \sqrt{576} = 24, \text{ and } 30 - 24 = 6. \text{ the versed sine.}$$

Table of versed sines, chords, and areas of circular segments, the semi-circle being unity, or $\frac{\cdot 7854}{2} = \cdot 3927.$

Height of segment in 100ths, of the radius from circumference.	Chord of segment, the diameter of circle being unity, or 1.	Area of segment, the area of semi-circle being unity, or 1.	Area of each 100th of the semi-circle on the radius from circumference.
·01	·142	·00042	·00042
·02	·198	·00125	·00085
·03	·241	·00234	·00109
·04	·279	·00364	·00130
·05	·312	·00512	·00148
·06	·339	·00677	·00165
·07	·366	·00857	·00180
·08	·391	·01050	·00193
·09	·414	·01254	·00204
·10	·438	·01468	·00214
·11	·456	·01690	·00222
·12	·476	·01922	·00232
·13	·494	·02163	·00241
·14	·512	·02413	·00250
·15	·528	·02672	·00259
·16	·545	·02940	·00268
·17	·560	·03216	·00276
·18	·576	·03500	·00284
·19	·590	·03791	·00291
·20	·600	·04088	·00297
·21	·614	·04390	·00302
·22	·627	·04699	·00309
·23	·639	·05015	·00316
·24	·650	·05338	·00323
·25	·662	·05667	·00329

Height of segment in 100ths, of the radius from circumference.	Chord of segment, the diameter of circle being unity, or 1.	Area of segment, the area of semi-circle being unity, or 1.	Area of each 100th of the semi-circle on the radius from circumference.
·26	·673	·06001	·00343
·27	·684	·06340	·00339
·28	·696	·06684	·00344
·29	·705	·07033	·00349
·30	·716	·07387	·00354
·31	·725	·07746	.00359
·32	·734	·08110	·00364
·33	·743	·084795	·003695
·34	·752	·08854	·003745
·35	·760	·09232	·00378
·36	·769	·09614	·00382
·37	·778	·10000	·00386
·38	·787	·10390	·00390
·39	·794	·10784	·00394
·40	·800	·11182	·00398
·41	·807	·11584	·00402
·42	·815	·11990	·00406
·43	·823	·12400	·00410
·44	·828	·12813	·00413
·45	·836	·13229	·00416
·46	·842	·13648	·00419
·47	·849	·14070	·00422
·48	·855	·14495	·00425
·49	·861	·14923	·00428
·50	·865	·15354	·00431
·51	·872	·15788	·00433
·52	·878	·16225	·00437
·53	·883	.16664	·00439
·54	·888	·171065	·004425
·55	·894	·17552	·004455

Height of segment in 100ths, of the radius from circumference.	Chord of segment, the diameter of circle being unity, or 1.	Area of segment, the area of semicircle being unity, or 1.	Area of each 100th of the semicircle on the radius from circumference.
·56	·898	·180005	·004485
·57	.903	·18451	·004505
·58	·908	·189045	·004535
·59	·912	·19360	·004555
·60	·917	·19817	·00457
·61	·922	·202755	·004585
·62	·926	·20736	·004605
·63	·931	·211995	·004635
·64	·934	·21665	·004655
·65	·939	·221325	·004675
·66	·943	·22602	·004695
·67	·946	·230735	·004715
·68	·949	·23547	·00475
·69	·953	·24022	·00476
·70	·955	·24498	·00477
·71	·958	·24975	·00479
·72	·961	·25455	·00481
·73	·964	·25935	·00483
·74	·967	·26418	·00484
·75	·970	·26902	·00485
·76	·973	·27387	·00486
·77	·975	·27873	·00487
·78	·977	·28360	·00488
·79	·979	·28848	·00489
·80	·981	·29337	·004875
·81	·983	·298275	·004905
·82	·985	·303198	·004923
·83	·987	·308130	·004932
·84	·989	·313066	·004936
·85	·991	·318008	·004942

Height of segment in 100ths, of the radius from circumference.	Chord of segment, the diameter of circle being unity, or 1.	Area of segment, the area of semicircle being unity, or 1.	Area of each 100th of the semicircle on the radius from circumference.
·86	·993	·322953	·004945
·87	·994	·327902	·004949
·88	·995	·832858	·004956
·89	·996	·337817	·004959
·90	·997	·342780	·004963
·91	·998	·347754	·004974
·92	·9982	·352739	·004985
·93	·9983	·357729	·004990
·94	·9984	·362721	·004992
·95	·9985	·367715	·004994
·96	·9986	·372710	·004995
·97	·9987	·377706	·004996
·98	·9988	·382703	·004997
·99	·9999	·387701	·004998
1·00	1·0000	·392700	·004999

Application of the preceding Table to practical purposes.

To find the area of the segment of a circle, the versed sine and diameter of circle being given.

Rule.—Divide the versed sine by the radius of the circle, the quotient is the versed sine in 100ths of unity; multiply the corresponding tabular area of unity by the square of the circle's diameter, and the product is the area of the segment in terms of the diameter.

Ex. The diameter of a circle equal 50 feet, required the area of a corresponding segment whose versed sine equal 18.

$\frac{18}{25} = ·72$,—In the first column and opposite to which in the third column is ·25455, or area of unity; hence, $·25455 \times 50^2 = 636·35$ square feet, the area.

The diameter of a circle and area of a required corresponding segment being given, to find the height or versed sine of the segment requisite to be cut off.

Rule.—Divide the given area of the segment by the square of the circle's diameter, the quotient is the tabular area of unity, opposite to which, under heights of segments, is the versed sine of unity; multiply this versed sine by the radius of the circle, and the product is the versed sine of the required segment in terms of the diameter.

Ex. Suppose the diameter of a circle equal 6 feet, and from which a segment containing 5 areal feet is required, what must be the height or versed sine of the segment?

$\frac{5}{36} = \cdot13888$, the nearest tabular area, is ·14070, and opposite to which is ·47. Hence $\cdot47 \times 3 = 1\cdot41$ feet the height, or versed sine required.

To find the chord of a segment, the diameter of circle and versed sine of the segment being given.

Rule.—Divide the versed sine by the radius of the circle, ; multiply the tabular length of chord (corresponding to the quotient) by the diameter of the circle, and the product is the chord of the segment in terms of the diameter.

Ex. Suppose a circle whose diameter is 40 feet and versed sine 10, required the length of chord.

$\frac{10}{20} = \cdot50$, opposite to which in the table (under chords of segments) is ·865; hence, $\cdot865 \times 40 = 34\cdot6$ feet, the length of chord.

Combined Examples.

1. Required the area of the segment of a circle whose length of chord equal 20 feet, and versed sine 4.

$\frac{20}{2} = 10^2 + 4^2 = \frac{116}{8} = 14\cdot5$ the radius, then

$\frac{4}{14\cdot5} = \cdot2758$, tabular area for $\cdot27 = \cdot0634$, and opposite to it in next column is $\cdot00339 \times \cdot0058 = \cdot0019662 + \cdot0634 = \cdot0654$; hence, 29 feet, or the diameter squared $= 841$, and $\cdot0654 \times 841 = 55\cdot0014$ square feet the area of segment.

2. An iron cylindrical boiler 20 feet in length and 5½ feet in diameter, weighing 2¾ tons, is to be made securely water tight, so that it may be floated up a river of fresh water to its destination; required the quantity of water that it will displace, and the depth of its greatest immersion on the radius.

1 ton = 2240 lbs. × 2·75 = 6160 total weight in lbs.;
And 1 cubic foot of fresh water = 62·5 lbs.; hence
$\frac{6160}{62\cdot5} = 98\cdot56$ cubic feet of water displaced,
and $\frac{98\cdot56}{20} = 4\cdot928$ areal feet of segment immersed;
Then $\frac{4\cdot928}{5\cdot5^2} = \cdot16291$ tabular area, the nearest to which is ·16225; opposite to it in the first column, or heights of segments, is ·52, and ·52 × 2·75 or radius = 1·43 feet, its greatest depth of immersion if the weights of each end be equal.

Rules for Circumferences and Areas of Circles.

For the sake of brevity, the following tables are not extended beyond 40 inches, larger diameters not being frequently required in practice; and when any hurried answer is required, and not found in the tables, half its diameter, as in the following example, will generally expedite.

Let the following be required relative to a 50-inch circle, half of 50 = 25.

As per Table.

Circum. of 25 = 78·5398 × 2 = 157·0796 cir. of 50.
Square of 25 = 625 × 2 = 2500 square of 50.
Cube of 25 = 1562 × 8 = 125000 cube of 50.
Area of 25 = 490·8739 × 4 = 1963·4956 area of 50.
Side of = sq. of 25 = 22·1557 × 2 = 44·3114 side of = sq. of 50
and so of any other diameter, and doubling the diameter again if required.

TABLES OF CIRCUMFERENCES AND AREAS OF CIRCLES.

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = Square.
$\frac{1}{16}$	·1963	·0039	·00024	·0030	·0554
$\frac{1}{8}$	·3927	·0156	·00195	·0122	·1107
$\frac{3}{16}$	·5890	·0351	·00659	·0276	·1661
$\frac{1}{4}$	·7854	·0625	·01562	·0490	·2115
$\frac{5}{16}$	·9817	·0976	·03051	·0767	·2669
$\frac{3}{8}$	1·1781	·1406	·05273	·1104	·3223
$\frac{7}{16}$	1·3744	·1914	·08374	·1503	·3771
$\frac{1}{2}$	1·5708	·25	·125	·1963	·4331
$\frac{9}{16}$	1·7671	·3164	·17797	·2485	·4995
$\frac{5}{8}$	1·9635	·3906	·24414	·3068	·5438
$\frac{11}{16}$	2·1598	·4726	·32495	·3712	·6093
$\frac{3}{4}$	2·3562	·5625	·42187	·4417	·6646
$\frac{13}{16}$	2·5525	·6601	·53637	·5185	·7200
$\frac{7}{8}$	2·7489	·7656	·66992	·6013	·7754
$\frac{15}{16}$	2·9452	·8789	·81397	·6903	·8308
1 *in.*	3·1416	1	1	·7854	·8862
$\frac{1}{16}$	3·3379	1·1289	1·19946	·8861	·9416
$\frac{1}{8}$	3·5343	1·2656	1·42381	·9940	·9969
$\frac{3}{16}$	3·7306	1·4101	1·67456	1·1075	1·0524
$\frac{1}{4}$	3·9270	1·5625	1·95312	1·2271	1·0775
$\frac{5}{16}$	4·1233	1·7226	2·26098	1·3529	1·1631
$\frac{3}{8}$	4·3197	1·8906	2·59960	1·4848	1·2185
$\frac{7}{16}$	4·5160	2·0664	2·97045	1·6229	1·2740
$1\frac{1}{2}$	4·7124	2·25	3·375	1·7671	1·3293
$\frac{9}{16}$	4·9087	2·4414	3·81469	1·9175	1·3846
$\frac{5}{8}$	5·1051	2·6406	4·29101	2·0739	1·4401
$\frac{11}{16}$	5·3014	2·8476	4·80541	2·2365	1·4954
$\frac{3}{4}$	5·4978	3·0625	5·35937	2·4052	1·5508
$\frac{13}{16}$	5·6941	3·2851	5·95434	2·5801	1·6062
$\frac{7}{8}$	5·8905	3·5156	6·59179	2·7611	1·6616
$\frac{15}{16}$	6·0868	3·7539	7·27319	2·9483	1·7170

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
2 *in.*	6·2832	4	8	3·1416	1·7724
$\frac{1}{16}$	6·4795	4·2539	8·7736	3·3411	1·8278
$\frac{1}{8}$	6·6759	4·5156	9·5957	3·5465	1·8831
$\frac{3}{16}$	6·8722	4·7851	10·4675	3·7582	1·9385
$\frac{1}{4}$	7·0686	5·0625	11·3906	3·9760	1·9939
$\frac{5}{16}$	7·2649	5·3476	12·3663	4·2001	2·0493
$\frac{3}{8}$	7·4613	5·6406	13·3964	4·4302	2·1047
$\frac{7}{16}$	7·6576	5·9414	14·4822	4·6664	2·1601
2½	7·8540	6·25	15·625	4·9087	2·2155
$\frac{9}{16}$	8·0503	6·5664	16·8265	5·1573	2·2709
$\frac{5}{8}$	8·2467	6·8906	18·0878	5·4119	2·3262
$\frac{11}{16}$	8·4430	7·2226	19·4108	5·6727	2·3816
$\frac{3}{4}$	8·6394	7·5625	20·7968	5·9395	2·4370
$\frac{13}{16}$	8·8357	7·9101	22·2472	6·2126	2·4924
$\frac{7}{8}$	9·0321	8·2656	23·7636	6·4918	2·5478
$\frac{15}{16}$	9·2284	8·6289	25·3474	6·7772	2·6032
3 *in.*	9·4248	9	27	7·0686	2·6586
$\frac{1}{16}$	9·6211	9·3789	28·7228	7·3662	2·7140
$\frac{1}{8}$	9·8175	9·7656	30·5175	7·6699	2·7694
$\frac{3}{16}$	10·0138	10·1601	32·3853	7·9798	2·8247
$\frac{1}{4}$	10·2102	10·5625	34·3281	8·2957	2·8801
$\frac{5}{16}$	10·4065	10·9726	36·3467	8·6179	2·9355
$\frac{3}{8}$	11·6029	11·3906	38·4433	8·9462	2·9909
$\frac{7}{16}$	11·7992	11·8164	40·6178	9·2806	3·0463
3½	10·9956	12·25	42·875	9·6211	3·1017
$\frac{9}{16}$	11·1919	12·6914	45·2031	9·9678	3·1570
$\frac{5}{8}$	11·3883	13·1406	47·6347	10·3206	3·2124
$\frac{11}{16}$	11·5846	13·5976	49·9461	10·6796	3·2678
$\frac{3}{4}$	11·7810	14·0625	52·7343	11·0446	3·3232
$\frac{13}{16}$	11·9773	14·5351	55·3930	11·4159	3·3786
$\frac{7}{8}$	12·1737	15·1056	58·1855	11·7932	3·4340
$\frac{15}{16}$	12·3700	15·5039	61·0256	12·1768	3·4984

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
4 *in.*	12·5664	16	64	12·5664	3·5448
$\frac{1}{16}$	12·7627	16·5039	67·0471	12·9622	3·6002
$\frac{1}{8}$	12·9591	17·0156	70·1894	13·3640	3·6555
$\frac{3}{16}$	13·1554	17·5351	73·4282	13·7721	3·7110
$\frac{1}{4}$	13·3518	18·0625	76·7656	14·1862	3·7663
$\frac{5}{16}$	13·5481	18·5976	80·2021	14·6066	3·8217
$\frac{3}{8}$	13·7445	19·1406	83·7402	15·0331	3·8771
$\frac{7}{16}$	13·9408	19·6914	87·3804	15·4657	3·9325
4½	14·1372	20·25	91·125	15·9043	3·9880
$\frac{9}{16}$	14·3335	20·8164	94·9748	16·3492	4·0433
$\frac{5}{8}$	14·5299	21·3906	98·9316	16·8001	4·0987
$\frac{11}{16}$	14·7262	21·9726	101·8965	17·2573	4·1541
$\frac{3}{4}$	14·9226	22·5625	107·1718	17·7205	4·2095
$\frac{13}{16}$	15·1189	23·1601	111·4679	18·1900	4·2648
$\frac{7}{8}$	15·3153	23·7656	115·8574	18·6655	4·3202
$\frac{15}{16}$	15·5716	24·3789	120·2708	19·1472	4·3756
5 *in.*	15·7080	25	125	19·6350	4·4310
$\frac{1}{16}$	15·9043	25·6289	129·7463	20·1290	4·4864
$\frac{1}{8}$	16·1007	26·2656	134·6113	20·6290	4·5417
$\frac{3}{16}$	16·2970	26·9101	138·5961	21·1252	4·5971
$\frac{1}{4}$	16·4934	27·5625	144·7031	21·6475	4·6525
$\frac{5}{16}$	16·6897	28·2226	149·9306	22·1661	4·7079
$\frac{3}{8}$	16·8861	28·8906	155·2871	22·6907	4·7633
$\frac{7}{16}$	17·0824	29·5664	160·7673	23·2215	4·8187
5½	17·2788	30·25	166·375	23·7583	4·8741
$\frac{9}{16}$	17·4751	30·9414	172·1115	24·3014	4·9294
$\frac{5}{8}$	17·6715	31·6406	177·9785	24·8505	4·9848
$\frac{11}{16}$	17·8678	32·3476	183·9669	25·4058	5·0402
$\frac{3}{4}$	18·0642	33·0625	190·1093	25·9672	5·0956
$\frac{13}{16}$	18·2605	33·7851	196·3759	26·5348	5·1510
$\frac{7}{8}$	18·4569	34·5156	202·7792	27·1085	5·2064
$\frac{15}{16}$	18·6532	35·2539	209·3130	27·6884	5·2618

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
6 *in.*	18·8496	36	216	28·2744	5·3172
$\frac{1}{16}$	19·0459	36·7539	222·8205	28·8665	5·3726
$\frac{1}{8}$	19·2423	37·5156	229·7832	29·4647	5·4280
$\frac{3}{16}$	19·4386	38·2851	236·8890	30·0798	5·4834
$\frac{1}{4}$	19·6350	39·0625	244·1406	30·6796	5·5388
$\frac{5}{16}$	19·8313	39·8476	249·2654	31·2964	5·5942
$\frac{3}{8}$	20·0277	40·6406	259·0839	31·9192	5·6495
$\frac{7}{16}$	20·2240	41·4414	266·7790	32·5481	5·7049
6½	20·4204	42·25	274·625	33·1831	5·7603
$\frac{9}{16}$	20·6167	43·0664	282·6232	33·8244	5·8157
$\frac{5}{8}$	20·8131	43·8906	290·7753	34·4717	5·8711
$\frac{11}{16}$	21·0094	44·7226	299·0823	35·1252	5·9265
$\frac{3}{4}$	21·2058	45·5625	307·5468	35·7847	5·9819
$\frac{13}{16}$	21·4021	46·4101	316·1688	36·4505	6·0373
$\frac{7}{8}$	21·5985	47·2656	324·9511	37·1224	6·0927
$\frac{15}{16}$	21·7948	48·1289	333·8943	37·8005	6·1480
7 *in.*	21·9912	49	343	38·4846	6·2034
$\frac{1}{16}$	22·1875	49·8789	349·5702	39·1749	6·2588
$\frac{1}{8}$	22·3839	50·7656	361·7040	39·8713	6·3142
$\frac{3}{16}$	22·5802	51·6601	371·3070	40·5469	6·3096
$\frac{1}{4}$	22·7766	52·5625	381·0781	41·2825	6·4350
$\frac{5}{16}$	22·9729	53·4726	391·0184	41·9974	6·4904
$\frac{3}{8}$	23·1693	54·3306	401·1308	42·7184	6·5358
$\frac{7}{16}$	23·3656	55·3164	411·4158	43·4455	6·5912
7½	23·5620	56·25	421·875	44·1787	6·6465
$\frac{9}{16}$	23·7583	57·1914	432·5100	44·9181	6·7020
$\frac{5}{8}$	23·9547	58·1406	443·3222	45·6636	6·7573
$\frac{11}{16}$	24·1510	59·0976	454·3129	46·4153	6·8127
$\frac{3}{4}$	24·3474	60·0625	465·4843	47·1730	6·8681
$\frac{13}{16}$	24·5437	61·0351	476·8368	47·9370	6·9235
$\frac{7}{8}$	24·7401	62·0156	488·3730	48·7070	6·9789
$\frac{15}{16}$	24·9364	63·0039	500·0935	49·4833	7·0343

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
8 *in.*	25·1328	64	512	50·2656	7·0897
1/16	25·3291	65·0039	524·1939	51·0541	7·1451
1/8	25·5255	66·0156	536·3769	51·8486	7·2005
3/16	25·7218	67·0351	548·8499	52·8994	7·2559
1/4	25·9182	68·0625	561·5156	53·4562	7·3112
5/16	26·1145	69·0976	574·3739	54·2748	7·3666
3/8	26·3109	70·1406	587·4277	55·0885	7·4220
7/16	26·5072	71·1914	600·6775	55·9138	7·4774
8½	26·7036	72·25	614·125	56·7451	7·5328
9/16	26·8999	73·3164	627·7717	57·5887	7·5882
5/8	27·0963	74·3906	641·6191	58·4264	7·6436
11/16	27·2926	75·4726	655·6683	59·7762	7·6990
3/4	27·4890	76·5625	669·9218	60·1821	7·7544
13/16	27·6853	77·6601	684·3797	60·9943	7·8098
7/8	27·8817	78·7656	699·0449	61·8625	7·8651
15/16	28·0780	79·8789	713·9177	62·7369	7·9205
9 *in.*	28·2744	81	729	63·6174	7·9760
1/16	28·4707	82·1289	744·2932	64·5041	8·0312
1/8	28·6671	83·2656	759·7988	65·3968	8·0866
3/16	28·8634	84·4101	775·5378	66·2957	8·1420
1/4	29·0598	85·5625	791·4531	67·2007	8·1974
5/16	29·2561	86·7226	807·8043	68·1120	8·2527
3/8	29·4525	87·8906	823·9746	69·0293	8·3081
7/16	29·6488	89·0664	840·5642	69·9528	8·3635
9½	29·8452	90·25	857·375	70·8823	8·4190
9/16	30·0415	91·4414	874·3084	71·8181	8·4743
5/8	30·2379	92·6406	891·6660	72·7599	8·5297
11/16	30·4342	93·8476	909·1487	73·7079	8·5851
3/4	30·6306	95·0625	926·8593	74·6620	8·6405
13/16	30·8269	96·2851	944·7976	75·6223	8·6959
7/8	31·0233	97·5156	962·9667	76·5887	8·7513
15/16	31·2196	98·7539	981·3669	77·5613	8·8066

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
10 *in.*	31·4160	100	1000	78·5400	8·8620
⅛	31·8087	102·5156	1037·970	80·5157	8·9728
¼	32·2014	105·0625	1076·890	82·5160	9·0836
⅜	32·5941	107·6406	1116·771	84·5409	9·1943
½	32·9868	110·25	1157·625	86·5903	9·3051
⅝	33·3795	112·8906	1199·462	88·6643	9·4159
¾	33·7722	115·5625	1242·296	90·7627	9·5267
⅞	34·1649	118·2656	1286·138	92·8858	9·6375
11 *in.*	34·5576	121	1331	95·0334	9·7482
⅛	34·9503	123·7656	1376·892	97·2053	9·8590
¼	35·3430	126·5625	1423·828	99·4021	9·9698
⅜	35·7357	129·3906	1471·818	101·6234	10·0806
½	36·1284	132·25	1520·875	103·8691	10·1914
⅝	36·5211	135·1406	1571·009	106·1394	10·3021
¾	36·9138	138·0625	1622·234	108·4342	10·4130
⅞	37·3065	141·0156	1674·560	110·7536	10·5237
12 *in.*	37·6992	144	1728	113·0976	10·6345
⅛	38·0919	147·0156	1782·564	115·4660	10·7453
¼	38·4846	150·0625	1838·265	117·8590	10·8560
⅜	38·8773	153·1406	1895·115	120·2766	10·9668
½	39·2700	156·25	1953·125	122·7187	11·0776
⅝	39·6627	159·3906	2012·306	125·1854	11·1884
¾	40·0554	162·5625	2072·671	127·6765	11·2991
⅞	40·4481	165·7656	2134·232	130·1923	11·4099
13 *in.*	40·8408	169	2197	132·7326	11·5206
⅛	41·2338	172·2656	2260·986	135·2974	11·6314
¼	41·6262	175·5626	2326·203	137·8867	11·7422
⅜	42·0189	178 8906	2392·661	140·5007	11·8530
½	42·4116	182·25	2460·375	143·1391	11·9637
⅝	42·8043	185·6406	2529·353	145·8021	12·0745
¾	43·1970	189·0625	2599·609	148·4896	12·1853
⅞	43·5897	192·5156	2671·154	151·2017	12·2961

Dia. or Root,	Circum.	Square.	Cube.	Area.	Side of = square.
14 *in.*	43·9824	196	2744	153·9384	12·4068
⅛	44·3751	199·5156	2818·157	156·6995	12·5176
¼	44·7676	203·0625	2893·640	159·4852	12·6284
⅜	45·1605	206·6406	2970·458	162·2956	12·7392
½	45·5532	210·25	3048·625	165·1303	12·8500
⅝	45·9459	213·8906	3128·150	167·9896	12·9607
¾	46·3386	217·5625	3209·046	170·8735	13·0715
⅞	46·7313	221·2656	3291·325	173·7820	13·1823
15 *in*	47·1240	225	3375	176·7150	13·2930
⅛	47·5167	228·7656	3460·079	179·6725	13·4038
¼	47·9094	232·5625	3546·578	182·6545	13·5146
⅜	48·3021	236·3906	3633·505	185·6612	13·6254
½	48·6948	240·25	3723·875	188·6923	13·7361
⅝	49·0875	244·1406	3814·696	191·7480	13·8470
¾	49·4802	248·0625	3906·984	194·8282	13·9577
⅞	49·8729	252·0156	4000·747	197·9330	14·0685
16 *in.*	50·2656	256	4096	201·0624	14·1792
⅛	50·6583	260·0156	4192·751	204·2162	14·2900
¼	51·0510	264·0625	4291·015	207·3946	14·4008
⅜	51·4437	268·1406	4390·802	210·5976	14·5115
½	51·8364	272·25	4492·125	213·8251	14·6223
⅝	52·2291	276·3906	4594·993	217·0772	14·7321
¾	52·6218	280·5625	4699·421	220·3537	14·8439
⅞	53·0145	284·7656	4805·419	223·6549	14·9547
17 *in.*	53·4072	289	4913	226·9806	15·0654
⅛	53·7999	293·2656	5022·173	230·3308	15·1762
¼	54·1926	297·5625	5132·953	233·7055	15·2869
⅜	54·5853	301·8906	5245·349	237·1049	15·3977
½	54·9780	306·25	5359·375	240·5287	15·5085
⅝	55·3707	310·6406	5475·040	243·9771	15·6193
¾	55·7634	315·0625	5592·359	217·4500	15·7301
⅞	56·1561	319·5156	5711·341	250·9475	15·8408

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = Square.
18 *in.*	56·5488	324	5832	254·4696	15·9516
⅛	56·9415	328·5156	5954·345	258·0161	16·0624
¼	57·3342	333·0625	6078·390	261·5872	16·1732
⅜	57·7269	337·6406	6204·146	265·1829	16·2839
½	58·1196	342·25	6331·625	268·8031	16·3947
⅝	58·5123	346·8906	6460·837	272·4479	16·5055
¾	58·9056	351·5625	6591·796	276·1171	16·6163
⅞	59·2977	356·2656	6724·513	279·8110	16·7270
19 *in.*	59·6904	361	6859	283·5294	16·8378
⅛	60·0831	365·7656	6995·267	287·2723	16·9486
¼	60·4758	370·5625	7132·328	291·0397	17·0600
⅜	60·8685	375·3906	7273·192	294·8312	17·1701
½	61·2612	380·25	7414·875	298·6483	17·2809
⅝	61·6539	385·1406	7558·384	302·4894	17 3917
¾	62·0466	390·0625	7703·734	306·3550	17·5025
⅞	62·4393	395·0156	7850·935	310·2452	17·6132
20 *in.*	62·8320	400	8000	314·1600	17·7240
⅛	63·2247	405·0156	8150·939	318·0992	17·8348
¼	63·6174	410·0625	8303·765	322·0630	17·9456
⅜	64·0101	415·1406	8458·489	326 0514	18·0563
½	64·4028	420·25	8615·125	330·0643	18·1671
⅝	64·7955	425·3906	8773·681	334·1018	18·2779
¾	65·1882	430·5625	8934·171	338·1637	18 3887
⅞	65·5809	435·7656	9096·607	342·2503	18·4995
21 *in.*	65·7936	441	9261	346·3614	18·6102
⅛	66·3663	446·2656	9427·360	350·4970	18·7210
¼	66·7590	451·5625	9595·703	354·6571	18·8318
⅜	67·1517	456·8906	9766·036	358 8419	18·9425
½	67·5444	462·25	9938·375	363·0511	19·0533
⅝	67·9371	467·6406	10112·72	367·2849	19·1641
¾	68·3298	473·0625	10289·11	371·5432	19·2749
⅞	68·7225	478·5156	10467·52	375·8261	19 3857

Dia. or Root	Circum.	Square.	Cube.	Area.	Side of = square.
22 *in.*	69·1152	484	10648	380·1336	19·4964
⅛	69·5079	489·5156	10830·53	384·4655	19·6072
¼	69·9006	495·0625	11015·14	388·8220	19·7180
⅜	70.2933	500·6406	11201·83	393·2031	19·8287
½	70·6860	506·25	11390·62	397·6087	19·9395
⅝	71·0787	511·8906	11581·52	402·0388	20·0503
¾	71·4714	517·5625	11774·54	406·4935	20·1611
⅞	71·8641	523·2656	11969·70	410·9728	20·2719
23 *in.*	72·2568	529	12167	415·4766	20·3826
⅛	72·6495	534·7656	12366·45	420·0049	20·4934
¼	73·0422	540·5625	12568·07	424·5577	20·6042
⅜	73·4349	546·3906	12771·88	429·1352	20·7150
½	73·8276	552·25	12977·87	433·7371	20·8257
⅝	74·2203	558·1406	13185·98	438·3636	20·9365
¾	74·6130	564·0625	13396·48	443·0146	21·0473
⅞	75·0057	570·0156	13609·12	447·6992	21·1581
24 *in.*	75·3984	576	13824	452·3904	21·2688
⅛	75·7911	582·0156	14041·126	457·1150	21·3796
¼	76·1838	588·0625	14260·515	461·8642	21·4904
⅜	76·5765	594·1406	14482·177	466·6380	21·6012
½	76·9692	600·25	14706·125	471·4363	21·7119
⅝	77·3619	606·3906	14932·368	476·2592	21·8227
¾	77·7546	612·5625	15160·921	481·1065	21·9335
⅞	78·1473	618·7656	15391·794	485·9785	22·0443
25 *in.*	78·5400	625	15625	490·8750	22·1550
⅛	78·9327	631·2656	15860·548	495·7960	22·2658
¼	79·3254	637·5625	16098·453	500·7415	22·3766
⅜	79·7181	643·8906	16338·323	505·7117	22·4873
½	80·1108	650·25	16581·375	510·7063	22·5981
⅝	80·5035	656·6406	16826·415	515·7255	22·7089
¾	80·8962	663·0625	17073·859	520·7692	22·8197
⅞	81·2889	669·5156	17323·716	525·8375	22·9305

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
26 *in.*	81·6816	676	17576	530·9304	23·0412
⅛	82·0743	682·5156	17830·720	536·0477	23·1520
¼	82·4670	689·0625	18087·890	541·1896	23·0628
⅜	82·8597	695·6406	18347·520	546·3561	23·3735
½	83·2524	702·25	18609·625	551·5471	23·4843
⅝	83·6451	708·8906	18874·212	556·7627	23·5951
¾	84·0378	715·5625	19141·296	562·0027	23·7088
⅞	84·4305	722·2656	19410·888	567·2674	23·8166
27 *in.*	84·8232	729	19683	572·5566	23·9274
⅛	85·2159	735·7656	19957·642	577·8703	24·0382
¼	85·6086	742·5625	20234·828	583·2085	24·1490
⅜	86·0013	749·3906	20514·567	588·5714	24·2598
½	86·3940	756·25	20796·875	593·9587	24·3705
⅝	86·7867	763·1406	21081·759	599·3706	24·4813
¾	87·1794	770·0625	21369·234	604·8070	24 5921
⅞	87·5721	777·0156	21659·309	610·2680	24·7029
28 *in.*	87·9648	784	21952	615·7536	24·8136
⅛	88·3575	791·0156	22247·313	621·2636	24·9244
¼	88·7502	798·0625	22545·265	626·7982	25·0351
⅜	89·1429	805·1406	22845·864	632·3574	25·1459
½	89·5356	812·25	23149·125	637·9411	25·2567
⅝	89·9283	819·3906	23455·056	643·5494	25·3675
¾	90·3210	826·5625	23763·671	649·1821	25·4783
⅞	90·7137	833·7656	24074·981	654·8395	25·5891
29 *in.*	91·1064	841	24389	660·5214	25·6998
⅛	91·4991	848·2656	24705·735	666·2278	25·8106
¼	91·8918	855·5625	25025·203	671·9587	25·9214
⅜	92·2845	862·8906	25347·411	677·7143	26·0325
½	92·6772	870·25	25672·375	683·4943	26·1429
⅝	93·0699	877·6406	26000·102	689·2989	26·2537
¾	93·4626	885·0625	26330·609	695·1280	26·3645
⅞	93·8553	892·5156	26663·903	700·9817	26·4783

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
30 *in.*	94·2480	900	27000	706·8600	26·5860
⅛	94·6407	907·5156	27338·907	712·7627	26·6967
¼	95·0334	915·0625	27680·640	718·6900	26·8075
⅜	95·4261	922·6406	28025·208	724·6419	26·9183
½	95·8188	930·25	28372·625	730·6183	27·0291
⅝	96·2115	937·8906	28722·899	736·6193	27·1398
¾	96·6042	945·5625	29076·046	742·6447	27·2506
⅞	96·9969	953·2656	29432·075	748·6948	27·3614
31 *in.*	97·3896	961	29791	754·7694	27·4722
⅛	97·7823	968·7656	30152·829	760·8685	27·5829
¼	98·1750	976·5625	30517·578	766·9921	27·6937
⅜	98·5677	984·3906	30885·255	773·1404	27·8045
½	98·9684	992·25	31255·875	779·3131	27·9153
⅝	99·3531	1000·140	31629·446	785·5104	28·0260
¾	99·7458	1008·062	32005·984	791·7322	28·1368
⅞	100·1385	1016·015	32385·497	797·9786	28·2476
32 *in.*	100·5312	1024	32768	804·2496	28·3584
⅛	100·9240	1032·015	33153·501	810·5450	28·4691
¼	101·3166	1040·062	33542·015	816·8650	28·5799
⅜	101·7093	1048·840	33956·314	823·2096	28·6912
½	102·1020	1056·25	34328·125	829·5787	28·8015
⅝	102·4947	1064·390	34725·743	835·9724	28·9122
¾	102·8874	1072·562	35026·421	842·3905	29·0230
⅞	103·2801	1080·765	35530·169	848·8333	29·1338
33 *in.*	103·6728	1089	35937	855·3006	29·2446
⅛	104·0655	1097·265	36354·928	861·7924	29·3553
¼	104·4582	1105·562	36759·944	868·3087	29·4661
⅜	104·8509	1113·890	37256·088	874·8497	29·5769
½	105·2436	1122·25	37595·375	881·4151	29·6877
⅝	105·6363	1130·640	38017·784	888·0051	29·7985
¾	106·0290	1139·062	38443·352	894·6196	29·9092
⅞	106·4217	1147·515	38872·088	901·2587	30·0200

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
34 *in.*	106·8144	1156	39304	907·9224	30·1308
⅛	107·2071	1164·515	39738·288	914·6105	30·2416
¼	107·5998	1173·062	40177·384	921·3232	30·3523
⅜	107·9925	1181·640	40618·888	928·0605	30·4631
½	108·3852	1190·25	41063·625	934·8223	30·5739
⅝	108·7779	1198·890	41511·576	941·6087	30·6847
¾	109·1706	1207·562	41962·792	948·4195	30·7954
⅞	109·5633	1216·265	42417·256	955·2550	30·9062
35 *in.*	109·9560	1225	42875	962·1150	31·0170
⅛	110·3487	1233·765	43352·016	968·9995	31·1278
¼	110·7414	1242·562	43800·320	975·9085	31·2386
⅜	111·1341	1251·390	44267·944	982·8422	31·3493
½	111·5268	1260·25	44738·875	989·8003	31·4601
⅝	111·9195	1269·140	45213·120	996·7830	31·5709
¾	112·3122	1278·062	45690·728	1003·7902	31·6817
⅞	112·7049	1287·015	46171·680	1010·8220	31·7924
36 *in.*	113·0976	1296	46656	1017·8784	31·9032
⅛	113·4903	1308·015	47252·063	1024·9592	32·0139
¼	113·8830	1314·062	47634·765	1032·0646	32·1247
⅜	114·2757	1323·140	48129·239	1039·1946	32·2355
½	114·6684	1332·25	48627·125	1046·3941	32·3463
⅝	115·0611	1341·390	49128·430	1053·5281	32·4570
¾	115·4538	1350·562	49633·171	1060·7317	32·5678
⅞	115·8465	1359·765	50141·356	1067·9599	32·6786
37 *in.*	116·2392	1369	50653	1075·2126	32·7894
⅛	116·6319	1378·265	51168·110	1082·4898	32·9001
¼	117·0246	1387·562	51686·703	1089·7915	33·0109
⅜	117·4173	1396·890	52208·786	1097·1179	33·0217
½	117·8100	1406·25	52734·375	1104·4687	33·2325
⅝	118·2027	1415·640	53263·477	1111·8441	33·3432
¾	118·5954	1425·062	53796·109	1119·2440	33·4540
⅞	118·9881	1434·515	54332·278	1126·6685	33·5648

Dia. or Root.	Circum.	Square.	Cube.	Area.	Side of = square.
38 *in.*	119·3808	1444	54872	1134·1176	33·6756
⅛	119·7735	1453·515	55415·282	1141·5911	33·7863
¼	120·1662	1463·062	55962·140	1149·0892	33·8971
⅜	120·5589	1472·640	56512·583	1156·6119	34·0079
½	120·9516	1482·25	57066·625	1164·1591	34·1187
⅝	121·3443	1491·890	57624·274	1171·7309	34·2294
¾	121·7370	1501·562	58185·546	1179·3271	34·3402
⅞	122·1297	1511·265	58750·450	1186·9480	34·4510
39 *in.*	122·5224	1521	59319	1194·5934	34·5618
⅛	122·9151	1530·765	59891·204	1202·2633	34·6725
¼	123·3078	1540·562	60466·078	1209·9577	34·7833
⅜	123·7005	1550·390	61046·629	1217·6768	34·8941
½	124·0932	1560·25	61629·875	1225·4203	35·0049
⅝	124·4859	1570·140	62216·822	1233·1884	35·1156
¾	124·8786	1580·062	62807·484	1240·9810	35·2264
⅞	125·2713	1590·015	63401·872	1248·7982	35·3372
40 *in.*	125·6640	1600	64000	1256·6400	35·4480

The Lineal, Square, and Cubic Foot of different Countries, given in British inches.

Countries.	Lineal Foot.	Square Foot.	Cubic Foot.
Austria	12·45	155·002	1929·781
Belgium	11·24	126·337	1420·035
China	12·58	158·256	1990·865
Germany	11·28	127·238	1435·249
Holland	11·16	124·545	1389·929
Italy	12·72	161·798	2058·076
Portugal	12·94	167·444	2166·720
Prussia.................	12·19	148·596	1811·386
Rome	11·72	137·358	1609·840
Russia	13·75	189·062	2599·609
Spain...................	11·12	123·654	1375·037
Sweden..................	11·68	136·422	1593·414

NOTE.—The British lineal foot is used generally throughout America, the British West Indies, and Australia.

Table of Commission or Discount.

Rate per cent.	Rate per £ in pence, decimally.	Rate per £ to the nearest fraction of current money.		Rate per shilling in pence, decimally.	Rate per shilling to the nearest fraction of current money.	Rate per cent.	Rate per £ in pence, decimally.	Rate per £ to the nearest fraction of current money.		Rate per shilling in pence, decimally.	Rate per shilling to the nearest fraction of current money.
		s.	d.		d.			s.	d.		d.
½	1·2		1¼	·06		13	31·2	2	7½	1·56	
⅝	1·5		1½	·075		13½	32·4	2	8½	1·62	
¾	1·8		1¾	·09		14	33·6	2	9½	1·68	
⅞	2·1		2	·105		14½	34·8	2	11	1·74	
1	2·4		2½	·12		15	36·0	3	0	1·8	1¾
1½	3·6		3½	·18		15½	37·2	3	1¼	1·86	
2	4·8		5	·24		16	38·4	3	2½	1·92	
2½	6·0		6	·3	¼	16½	39·6	3	3½	1·98	
3	7·2		7¼	·36		17	40·8	3	5	2·04	2
3½	8·4		8½	·42		17½	42·0	3	6	2·1	
4	9·6		9½	·48		18	43·2	3	7¼	2·16	
4½	10·8		11	·54	½	18½	44·4	3	8½	2·22	
5	12·0	1	0	·6		19	45·6	3	9½	2·28	2¼
5½	13·2	1	1¼	·66		19½	46·8	3	11	2·34	
6	14·4	1	2½	·72		20	48·0	4	0	2·4	
6½	15·6	1	3½	·78	¾	20½	49·2	4	1½	2·46	
7	16·8	1	5	·84		21	50·4	4	2½	2·52	2½
7½	18·0	1	6	·9		21½	51·6	4	3½	2·58	
8	19·2	1	7¼	·96		22	52·8	4	5	2·64	
8½	20·4	1	8½	1·02	1	22½	54·0	4	6	2·7	
9	21·6	1	9½	1·08		23	55·2	4	7¼	2·76	2¾
9½	22·8	1	11	1·14		23½	56·4	4	8½	2·82	
10	24·0	2	0	1·2		24	57·6	4	9½	2·88	
10½	25·2	2	1¼	1·26	1¼	24½	58·8	4	11	2·94	
11	26·4	2	2½	1·32		25	60·0	5	0	3·0	3
11½	27·6	2	3½	1·38		27½	66·0	5	6	3·3	3¼
12	28·8	2	5	1·44		30	72·0	6	0	3·6	3½
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0½	0 7	0 1 2	0 4 8	4 13 4	2 1 8	0 6	0 5 0	0 4 2	0 10	0 6	0½
0¾	0 10½	0 1 9	0 7 0	7 0 0	3 2 6	0 9	0 7 6	0 6 3	1 3	0 9	0¾
1	1 2	0 2 4	0 9 4	9 6 8	4 3 4	0 12	0 10 0	0 8 4	1 8	1 0	1
1¼	1 5½	0 2 11	0 11 8	11 13 4	5 4 2	0 15	0 12 6	0 10 5	2 1	1 3	1¼
1½	1 9	0 3 6	0 14 0	14 0 0	6 5 0	0 18	0 15 0	0 12 6	2 6	1 6	1½
1¾	2 0½	0 4 1	0 16 4	17 6 8	7 5 10	1 1	0 17 6	0 14 7	2 11	1 9	1¾
2	2 4	0 4 8	0 18 8	18 13 4	8 6 8	1 4	1 0 0	0 16 8	3 4	2 0	2
2¼	2 7½	0 5 3	1 1 0	21 0 0	9 7 6	1 7	1 2 6	0 18 9	3 9	2 3	2¼
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2¾	3 2½	0 6 5	1 5 8	25 13 4	11 9 2	1 13	1 7 6	1 2 11	4 7	2 9	2¾
3	3 6	0 7 0	1 8 0	28 0 0	12 10 0	1 16	1 10 0	1 5 0	5 0	3 0	3
3¼	3 9½	0 7 7	1 10 4	30 6 8	13 10 10	1 19	1 12 6	1 7 1	5 5	3 3	3¼
3½	4 1	0 8 2	1 12 8	32 13 4	14 11 8	2 2	1 15 0	1 9 2	5 10	3 6	3½
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9½	11 1	1 2 2	4 8 8	88 13 4	39 11 8	5 14	4 15 0	3 19 2	15 10	9 6	9½
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11¾	13 8½	1 7 5	5 9 8	109 13 4	48 19 2	7 1	5 17 6	4 17 11	19 7	11 9	11¾
12	14 0	1 8 0	5 12 0	112 0 0	50 0 0	7 4	6 0 0	5 0 0	20 0	12 0	12

Table specifying the value of Moneys of Account of the principal places with which Britain has exchange transactions, taking silver at an estimated value of five shillings per ounce Troy.

		Are equal to	is equal to in S. & D. British		and giving for one £ sterling.
Amsterdam	100 centimes...	1 florin	1	8	11 flor. 97 cents...
Antwerp	The same as	Amsterdam.			
Berlin	30 sil. groschen	1 Pruss. dollar ...	2	10¾	6 doll. 27 s. g. ...
China	10 mace	1 tael	6	8	3 tael ....
Constantinople ..	40 paras	1 piastras	0	2¼	110 piastre ....
Copenhagen......	96 skillings ...	1 Reig. dollar......	2	2⅓	9 doll. 10 sk. ......
Frankfort	24½ guilders ...	1 mark	1	7⅞	12 3/40 guilders ......
Genoa	100 centisimi ..	1 lira Nuova	0	9⅓	15 li. 57 cents ....
Hamburg	16 schillings ...	1 mark	1	5½	13 mks. 10½ sch....
Havanna	100 cents.	1 dollar	4	6	4 doll. 44 cents....
Leghorn	100 centisimi ..	1 lira Toscana ...	0	8	30 li. 69 cents. ...
Lisbon	1000 reis	1 milreis	4	8	4 mil. 285 reis. ...
Madrid...	8 reals	1 dollar of plate...	3	1¾	6 doll. 2¾ reals ....
Malta	12 tari	1 scudi	1	8	12 scudo ....
New York.........	100 cents.	1 dollar	4	2	4 doll. 80 cents ...
Paris	100 centimes...	1 franc...............	0	9⅓	25 fr. 57 cents ....
Petersburg	100 copecks ...	1 rouble	3	1½	6 roub. 40 cop. ...
Rio Janeiro	1000 reis	1 milreis	2	7	7 mil. 117 reis ...
Venice	100 centisimi ..	1 lira Austriaca...	0	8 1/13	29 li. 52 cents ....
Vienna...	60 krewzers ...	1 florin	2	0 4/10	9 flor. 50 kr. ......

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